NATURE

No. 3987 SATURDAY, MARCH 30, 1946 Vol. 157

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Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number : Whitehall 8831
Telegrams : Phusis Lesquare London
Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone : Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad.

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RIVER FLOW IN GREAT BRITAIN

A GREAT amount of work remains to be done before we shall have an adequate knowledge of river flow in Britain and be in a position to plan the best use of its rivers for the supply of water, the provision of power and the maintenance of the rivers themselves. The recent issue by Captain W. N. McClean of a further instalment of the river-flow records at Loch Ness adds to our slowly accumulating knowledge, and is a timely reminder of the lack of attention to the subject. Largely through the enthusiastic advocacy of Captain McClean himself, the Inland Water Survey was started in 1933; and before the War, in spite of the very modest support from public funds, there appeared the two valuable volumes of the "Surface Water Year Book of Great Britain" for 1935–36 and 1936–37. Deficiencies notwithstanding, these gave promise of a great advance, and it is greatly to be hoped that their continuation may soon be resumed.

Appreciation of the importance of water supply for an ever-increasing range of industrial uses, as well as for domestic purposes, has spread rapidly in recent years, and has led to repeated inquiry into the circumstances which limit water resources in Great Britain. In spite of the vast quantities of water now used, it is still true that they represent just about 1 per cent of the total rainfall over the country. Of this ample rain a considerable but still minor fraction is lost by evaporation. The rest flows back to the sea. Some enters the rivers at once; some saturates the soil for short periods and then drains slowly into the streams; some pursues a longer course for a time as 'underground water' and later emerges from springs. Only an insignificant fraction may reach the sea by underground percolation without rejoining the surface flow.

Much effort has been devoted to attempts at measurement of the percentage of rainfall which percolates through the soil, and also the varying rates of evaporation from a free water-surface. But the attempts to apply these data to assessment of the proportions of rainfall which may be expected to appear as 'run-off' and as 'underground water' seem to show a very inadequate appreciation of the immense complexity of the factors involved. Surface-slope, vegetation, soil character and solid geology, local rainfall distribution in time and space as well as other factors set a problem of the greatest intricacy. Evaporation of water from the land can bear little direct relation to that from a free water-surface. An obvious major source of disagreement lies in the fact that the periods at which the water-surface shows greatest evaporation are commonly those when the land has practically no water to evaporate. How completely such measures fail to synchronize with the variations of river-flow has been demonstrated by E. G. Bilham (*Water and Water Engineering*, October 1937).

In all this complex, the two outstanding factors in relation to any watershed which may be readily

measured with precision are rainfall and river-flow, and from these measures all serious study of water problems must commence. The volume of rainfall and its distribution may be determined with any desired degree of accuracy by multiplication of gauges—though the general scantiness of our information even in this matter is perhaps rarely appreciated. But in regard to river-flow our lack of precise information is still dire. In his measurements of the flow of the River Ness and its tributaries, of the Aberdeenshire Dee and other rivers, Captain McClean has set a high standard of accuracy and completeness, with careful records of rainfall and its areal distribution, of other accompanying meteorological conditions, and of precise river-flow at various stations. He has also done much to show how such data may be analysed to reveal the causes of variation in flow, and how they may be applied to the solution of practical problems concerning the utilization of supplies and the proper assessment of desirable compensation water.

Even among those who have some familiarity with these matters, there must be few who will not have been surprised by the immense range in the rate of discharge of these Scottish rivers, and the still greater range revealed by the wider records now gathered by the Inland Water Survey. Cases in which the maximum flow exceeds the minimum by more than a hundred times are quite general, while ratios of more than a thousand to one are not infrequent among streams of very substantial size. It is these extremes of flow which are of prime importance to the engineer, the industrialist and the community. Their range and character constitute the distinctive peculiarities of different rivers, and a precise knowledge of them is the absolute pre-requisite of an intelligent and economic use of water resources. Intensive study of a substantial number of well-selected rivers, with careful analysis of the probable share of the various factors mentioned in the production of their individual characteristics, will doubtless enable us in due time usefully to predict the behaviour of a river from the geological, topographic and meteorological features of its basin. How completely unreliable are the estimates which may be attempted on the basis of present knowledge (unless founded on lengthy gauging of the individual stream) is best known to those who have been compelled to make or to use them.

While the extremes display the characteristics of the river, it is necessarily true that the longer the periods over which we average the flow, the smaller become the differences apparent in the behaviour of different streams; and some of these broader features are of much practical as well as theoretical importance. In the course of a year, every river must discharge to the sea practically the whole of the rainfall, less evaporation losses; with only small variations in the proportion due to the reservoir action of underground waters, which feed the streams during dry years and absorb more water during wet years. But although in this respect the behaviour of all rivers must be nearly identical, there are doubtless very substantial variations in the actual proportions of the total rainfall discharged on the average from different river basins (that is, variations in the total evaporation losses) concerning which our information is woefully inadequate.

Possibly one of the most dangerous figures, if only because it is the most frequently quoted, is the 'mean flow' of a river. Cursory analysis of the flow of a few representative but widely different rivers of Britain reveals that they all discharge three quarters of their total flow in about one third of the year. For the remaining two thirds of the time the 'average' flow is thus about three eighths of the annual 'mean'—a very considerable difference! As we turn attention to the shorter periods of more rapid flow, the peculiarities of the different rivers become increasingly marked. Thus one half of the total discharge may be made in rather less than one month, or in rather more than two; one quarter in less than two weeks or in nearly five; one eighth in as little as four days or as long as sixteen. Doubtless further examination will reveal a wider range, but these figures are enough to show how the individual peculiarities are increasingly seen in the very variable behaviour of the rivers during the flood periods.

The two "Surface Water Year Books" published by the Inland Water Survey before the War very naturally concentrated on an attempt to make good the almost total lack of accessible and systematized data. Most of the material was necessarily supplied by waterworks authorities, for whose help everyone must be very grateful. An inevitable consequence, however, is that a large percentage of the records represent the measurement of streams below reservoirs and intake-weirs, and therefore cannot show the natural flow. Such data have their own value, but for sound planning we must reach a real understanding of the natural flow and the causes of its variations in different basins. For this reason we may hope that future issues of this work, while still collecting all available data, will give the fullest information in relation to a well-selected series of rivers intensively studied. Co-operation of the Meteorological Office in the collection and analysis of complete weather data, and of the Geological Survey in estimation of the real hydrological characteristics of the ground concerned, would go far to produce results of the greatest value alike to science and to public economy.

STRUCTURAL INORGANIC CHEMISTRY

Structural Inorganic Chemistry
By Dr. A. F. Wells. Pp. viii + 590. (Oxford: Clarendon Press; London: Oxford University Press, 1945.) 25*s.* net.

SINCE the first studies of crystal structures were made by the Braggs in 1913, there has been an ever-increasing flow of structure analyses carried out, first by the X-ray method alone, and later in addition by other techniques. For some time, while investigators—largely physicists—were exploring the possibilities of the new science and establishing the sound

basis of technique without which the achievements of later times would not have been possible, the choice of substances for study was, from the point of view of the chemist, mineralogist or metallurgist, with notable exceptions, determined largely by fortuitous circumstances. In the years immediately preceding the Second World War, however, a growing majority of structural investigations were clearly undertaken, if not as integral parts of chemical or other researches, at least with the aim of extending knowledge of specific chemical topics rather than as ends in themselves; while, equally important, a large proportion of chemists had learnt to appreciate the significance of structure analysis and were influenced by its results in their attitude to teaching and research. One outcome of this mutual interaction between structure analysis and the older sciences has been the appearance of various monographs, and, to a lesser extent, the adoption of a new 'slant' in the treatment of old subjects in less specialized works; but it was probably true to say that no text-book of inorganic chemistry showed a complete assimilation of the results and implications of the new subject.

The work under review has been written because the author is convinced "that the structural side of inorganic chemistry cannot be put on a sound basis until this knowledge gained from the study of the solid state has been incorporated into chemistry as an integral part of that subject, and . . . that it is unsatisfactory merely to add information about the structures of solids to the descriptions of elements and compounds as usually presented in a systematic treatment of inorganic chemistry"; his book aims at answering the questions: "What is it [a compound] made of, what holds the constituent parts together, and how are they arranged?" This conviction is one which is undoubtedly shared by all who have given thought to the development of modern inorganic chemistry, and these aims, in fulfilment, could not fail to produce a book of great value to chemists. Unhappily, in my opinion, the author has interpreted the title of his book too narrowly, and has failed to appreciate that the study of the solid state is not the sole discipline which must become an integral part of structural inorganic chemistry if that subject is to have a sound basis. In particular, the question, "What holds the constituent parts together?", cannot be satisfactorily answered in a book which consistently ignores the contributions of kinetic and thermodynamic studies, which, for example, makes no reference to lattice energies, and states (p. 210) that "bond energies . . . are generally not of great use from the structural point of view". At many points throughout the book the reader experiences a sense of frustration when the discussion of a topic, often excellent from the 'structural' point of view, is terminated at a point when a most illuminating connexion with some other field could have been pointed out; a typical example is a section on colour (p. 231), in which the question of valency states of the metal ions in various intensely coloured compounds is discussed, without any hint that there might be some relation between the colour and the energetics of electron transfers between metal ions in different valency states.

It appears from the preface and introduction that the book is intended rather for instructional than for reference purposes, and the inclusion in Part I of a great deal of what is normally regarded as elementary general chemistry (atomic structure, bond types, states of aggregation, etc.) indicates that it is addressed to students rather than to teachers: this part is, however, greatly weakened by a general unevenness of treatment and by a looseness of style, both of which suggest that the author's experience of undergraduate teaching is very limited. In illustration of these points may be mentioned a very elementary discussion of the electromotive series on p. 68, whereas zero-point energy is introduced on p. 95 without any explanation; in a section on solution of gases in solids (pp. 126–127) no distinction is made between adsorption and absorption, while from the general discussion on states of aggregation (p. 117) a student might well be excused for concluding that *at a constant temperature* the kinetic energy of a molecule increases successively in passing from the solid phase to the liquid and then to the gaseous state. In places the looseness of style develops into inaccuracy, as in the statement of the relation between mosaic structure and extinction (p. 160). Apart from these defects in detail, it is in my opinion regrettable that space should have been devoted to an elementary treatment of a range of subjects already adequately covered in various modern text-books of general and physical chemistry, to the detriment of some topics more germane to the main theme, and to the complete exclusion of others, such as the nature of the metallic bond, and elementary lattice dynamics. The section on X-ray diffraction in Chapter 6 is an example of a subject which might have been more adequately treated; the discussion is at present not sufficiently extensive or critical to provide the non-specialist with the basis (which as the author truly says is very desirable) for forming his own judgment on the accuracy and limitations of X-ray structure analysis.

Narrowness of treatment is the major shortcoming of Dr. Wells' book, and a reviewer would be equally lacking in breadth of outlook if he emphasized unduly the lesser defects of a work which was prepared under war-time difficulties, and which, particularly in its systematic part (amounting to nearly two thirds of the book), presents in clear fashion a large amount of good descriptive material assembled from a wide variety of sources. The continued progress of research will add rapidly to the material available for such systematic discussion, and it may be hoped that in preparing the second edition which these additions will call for, the author will take the opportunity not only to broaden the basis of his treatment but also to remove the lesser blemishes which mar the present book.

E. G. Cox.

POLITICAL PHILOSOPHIES

The Open Society and its Enemies

By K. R. Popper. Vol. 1: The Spell of Plato. Pp. vii + 268. Vol. 2: The High Tide of Prophecy—Hegel, Marx and the Aftermath. Pp. v + 352. (London: George Routledge and Sons, Ltd., 1945.) 2 vols., 42*s*. net.

THIS is a book of great length (444 pages of text), great learning (168 pages of notes), but not of commensurate understanding. It is a pity, because its defects may conceal its undoubted merits. When Dr. Popper is not caricaturing writers whose views he dislikes—and he dislikes a great many—he has a useful contribution to make to political thought, and his general moral theory (mainly to be found in the

notes) is eminently sane and sensible. But for his passion for tilting at windmills he would have written a better and shorter book.

The first volume consists mainly of an attack on Plato—or rather, on views attributed to Plato with the help of ingenious special pleading and misdirected erudition. Dr. Popper does not try to understand Plato on his own terms, taking the dialogues as experiments in the art of discussion, in the light of the events and thoughts of Plato's own day. Instead, texts are extracted and interpreted in terms of the thought of our own day. Plato, in short, is accused of not being a nineteenth-century Liberal in politics. The urgent problems of Plato's day turned upon the extreme weakness and instability of the Greek cities, their suicidal faction fights and their tendency to oscillate between anarchy and tyranny. Modern problems about the extent and kind of governmental authority and the character of political institutions had scarcely appeared on the horizon. If they did appear it was mainly due to Plato himself. In the ancient world government, State and society had not yet been distinguished. Every State was as totalitarian as it knew how. To assign limits to the sphere of government beyond which it should not interfere in private affairs is a specifically Christian notion; to assign to government the duty of protecting the liberties of the subject is specifically modern. It is hopeless to try to put these ideas into Athenian democracy or the teaching of Sophists and Cynics; and then present Plato as opposing them after the manner of a modern Fascist. Dr. Popper would reduce Plato to a disgruntled old clubman (Gad, sir! Athens is going to the dogs!). There was a touch of this about Plato by the time he wrote "The Laws"; but a great deal more of far greater importance, Dr. Popper refuses to look at. He is probably right, though, when he says Plato confused individualism with egoism and supposed collectivism necessary for altruism. He is wrong if he supposes Plato's collectivism to resemble nineteenth-century collectivism. The true weakness of Plato's collectivism was well enough put by Aristotle; but Dr. Popper dislikes Aristotle even more than Plato, and ignores it.

The fact is, Dr. Popper's dislike of Plato and Aristotle is incidental; his real bugbear is what he calls 'historicism'. He sees it everywhere, in the most unexpected places. Historicism is stated to be the belief that human history proceeds according to a recognizable general law or pattern, so that the future is inevitable and can be predicted. This is a dangerous fallacy, but so obviously fallacious that a long book is not needed to refute it. Few people can really have swallowed it. Curiously enough, the arch-historicist, Marx, though put in his place, is treated very fairly; while Hegel, who may or may not have been a historicist in the sense stated, gets nothing but insults. In the end it appears that anybody with any philosophy of history, except Mr. Henry Ford's view that history is 'bunk', is liable to be accused of historicism. Indeed it is hard to see how Dr. Popper himself can escape; as he assumes it is possible by deliberate effort to alter social conditions, to lessen suffering and obtain more justice, liberty and equality. True, he holds that grandiose schemes and revolutions are useless and that we should tackle things piecemeal and in an experimental way, acquiring gradually a better social technology. All this is well argued. Still, if social technology is to be possible or anything to be learnt from political experiments, there must be some recognizable regularities in human history, and the Fordian philosophy must be discarded for one or other of the views Dr. Popper derides when anybody else expresses them.

While attacking historicism, Dr. Popper also castigates historians for their almost universal admiration for power-politics, when successful, and their blindness to its evils. This is well said. Incidentally, he commits a historical blunder in discussing nationalism, of which he sees only the black side. He speaks as though Rousseau invented the idea and Prussia was the first nationalist State (vol. 2, p. 48 *et seq.*). Rousseau merely repeated what French and British writers took for granted, that the Nation-State was the only political entity. As to when nationalism began; it is easy, writing from Scotland, to give a date: 1297. The trouble with the Prussians was that they started five hundred years too late. You cannot blame Rousseau or King Frederick or even Fichte and Hegel for that. If individuals are to be blamed, it should be Napoleon most of all. There is nothing like a foreign invader for fostering nationalism, equally in Scotland in the thirteenth century and Russia in the twentieth. After Napoleon, it should be Bismarck, who showed that aggressive war could be cheap, easy and profitable. From the point of view of Central Europe and with Germany in mind, Dr. Popper cannot see any redeeming feature of nationalism. But if the insane nationalism of Hitler nearly destroyed civilization, it was rival nationalisms that destroyed Hitler.

The reader who skips with discrimination can extract much of value and interest from Dr. Popper's work. It must be said in fairness too, after all these carping criticisms, that he has a pleasant and lively style of writing. Even when hitting out in the wrong direction, he does it with grace and vigour.

A. D. Ritchie.

THE ENEMIES OF STORED PRODUCTS

A Monograph of the Beetles associated with Store Products

By Dr. H. E. Hinton. Vol. 1. Pp. viii+443. (London: British Museum (Natural History), 1945.) 30*s*.

THE Second World War has taught us much new knowledge as regards the conserving of stored foods and other goods. The information specially gleaned during its strenuous years is a valuable legacy for the future. The present book is, in fact, the outcome of war-time investigations, for the increasing damage caused by insects to stored materials became a serious problem for the State and demanded prompt inquiry. In the preface it is stated that the volume owes its origin to representations made to the Department of Entomology of the British Museum (Natural History) by the Department of Scientific and Industrial Research and Prof. J. W. Munro. The outcome was, among other things, the seconding of Dr. H. E. Hinton from the Museum to the Ministry of Food. Among other duties he was deputed to write the present book.

Beetles are much the most important of the enemies of stored products. At least six hundred species are known to be implicated, and their numbers are continually being added to. They are grouped in more than thirty separate families, and are dis-

tributed in various countries, many being cosmopolitan or on the way to becoming so. These beetles are chiefly small or very small obscure kinds. Their accurate naming often presents real difficulties and even trained entomologists are often confused by their small size and close similarities. The author of this work is a skilled investigator of many of the smaller forms of beetles and of their life-histories. His excellent recent monographs have established his reputation, and consequently the choice of Dr. Hinton for the writing of the volume is an admirable one. Within its pages he has brought together all the available relevant information bearing upon about one third of the beetles associated with stored products. The groups so treated belong to twelve families, the most important of which are the Nitidulidæ, Lathridiidæ and Dermestidæ. The greater part of the information published in this book appears for the first time in its present form, with the exception of most of the section on the Lathridiidæ, which is taken from a recent paper by Hinton.

It may be said that the text is clearly written; the descriptions are detailed and very complete, and there are many carefully drawn figures portraying structural features of both adults and their larvæ. The author is to be congratulated upon the high standard of detailed scientific treatment that he has brought to bear upon his subject. For this reason, in particular, the book is likely to remain a standard one for many years. A second volume will be hoped for in the not too distant future in order to complete the monograph. Finally, it may be pointed out that a wide interpretation is given to the species included for treatment. Parasites and predators (Carabidæ and Staphylinidæ), for example, come in for full mention, besides beetles that occur where the commodities are normally stored; these latter may attack moulds, dead animals, the woodwork of rooms or containers and so forth. A. D. Imms.

SOIL EROSION IN AFRICA

Afrique, terre qui meurt

La dégradation des sols Africains sous l'influence de la Colonisation. Par Jean-Paul Harroy. Pp. x+557. (Bruxelles: Office International de Librairie, 1944.) 250 Belgian francs; 30*s*.

M. HARROY has attempted to relate the whole story of soil deterioration and erosion in Africa, as it has been described in the very extensive literature of the subject. Naturally, special attention is given to the Belgian Congo, of which the author had personal acquaintance before the War; but adequate attention is given to British and French territories as well. Indeed, very generous recognition is given to British work on both physical and social problems of soil conservation.

The author has compiled a comprehensive and well-balanced summary of one of the most urgent questions which confront all the Colonial Powers in Africa. He has of necessity had to confine his sources of information to literature published before the War; but little has appeared since 1939 that would have caused him to modify his general conclusions. There is, possibly, a greater awareness among those in authority of the urgency of soil conservation than M. Harroy believed to exist when he wrote the book. It is certainly not out of date; nevertheless, it leaves the impression that it is not up to date either. To British readers who have interested themselves in the subject, few of the statements and facts will be unknown. The assembling of so many facts and opinions about the fate of African soils under one cover is, however, unique.

The book begins with four chapters on the nature and factors of soil formation, especially under tropical conditions. These chapters were presumably thought necessary to complete an account of soil erosion, but little subsequent reference is made to the part which differences in soils, climate and topography have played in moulding the pattern of erosion in Africa. The author is more concerned with the effects of the impact of European colonization on the biotic equilibrium, and the modifications in the structure of human society required to readjust the equilibrium.

After describing the principal phenomena of land degradation—destruction of the natural vegetation, increasing floods and desiccation, and accelerated erosion—short accounts are given of the erosion conditions in the different African territories. In the next part of the book the author describes the transformation effected by European colonization in native society—religion, clothing, diet, education, health, population changes, political and legal administration, the disintegration of the tribe, urbanization, the colour bar, segregation, indented labour, forced cultivations, etc. He does not, however, always make clear the connexion between these several phenomena and the incidence of soil erosion; indeed, in some of his discussions neither the land nor erosion is mentioned. M. Harroy himself complains, with justification, that plant ecology and soils have been studied independently and mostly unrelatedly; the same is even more true of human ecology and soils—or human ecology and land utilization—as M. Harroy undoubtedly discovered when he wrote these chapters.

M. Harroy recognizes, however, that the restoration of soil fertility is essentially a problem in human ecology. Erosion is checked by direct measures on the soil—remedies of the first degree—such as afforestation, controlled grazing, irrigation, terracing, and so forth. These lead to remedies of the second degree—overall improvements in agriculture and radical modification of farming systems—that in turn lead to remedies of the third degree—the planned transformation of social conditions so that the second-degree remedies will work effectively. The bases of all soil conservation must be knowledge acquired through research and imparted through education of the masses, and co-operation at all levels—among farmers, tribes, specialists and even the metropolitan States. The chief role in, and responsibility for, soil conservation must be the State's, for the task is now too great and the consequences of failure would be too disastrous for it to be left to the spontaneous action of individuals. A plea is made for international action, at least between the three principal Colonial Powers in Africa, but perhaps an interchange of experiences is the most and the best that can be expected. This book brings out clearly the different attitudes adopted by the Belgian, British and French administrations to the human-ecological questions that arise at the points of contact of black and white, and it may be that more conflict than harmony would be created at this stage by attempts to unify the attack on a problem which each administration is tackling with some, if not complete, success according to its own ideals.

An Introduction to the Theory of Numbers

By Prof. G. H. Hardy and Prof. E. M. Wright. Second edition. Pp. xvi + 408. (Oxford: Clarendon Press; London: Oxford University Press, 1945.) 25*s*. net.

THIS book must be welcomed most warmly into the select class of Oxford books on pure mathematics which have reached a second edition. It obviously appeals to a large class of mathematical readers. One reason for this is clear. Any mathematician, not necessarily an expert in theory of numbers, can start almost anywhere in the book and turn over a few pages, and find a discussion of some problem which he can understand, and which is solved by elementary arguments in a comparatively short space; in spite of which it may have taken someone the best part of his life to solve it. It is sometimes objected that these problems are not important, and that they represent a sort of mathematical golf. This is largely a question of point of view. It may not be important to get little white balls into little round holes, but many people spend a great deal of time in doing so nevertheless.

Some substantial changes have been made in the text. The theory of quaternions has been rewritten, and now follows Hurwitz' method instead of Dickson's. The last chapter, on the geometry of numbers, has also been completely re-written in accordance with suggestions of Prof. Davenport. This is a popular subject just now owing to the activities of the 'Manchester school' of mathematicians, so that this chapter will be read with special interest.

E. C. T.

The Population of Great Britain

Current Trends and Future Problems. By Mark Abrams. (Published for the London Press Exchange, Ltd.) Pp. 51. (London: George Allen and Unwin, Ltd., 1945.) 3*s*. 6*d*. net.

THIS is the first of a series to be issued by the Research Department of the London Press Exchange as a contribution to the factual background of post-war problems affecting British industry and commerce. It adds little new to a much-discussed subject; but deserves attention because of the careful way in which the facts have been collected and the clear and attractive way in which they are presented. The causes of the decline in the birth-rate are discussed in a manner which would be wholly satisfactory to specialists and general readers, as are the remedies proposed by successive governments and independent observers. A useful appendix gives new vital statistics collected under the Population Statistics Act of 1938, and through them directs attention to the pattern of fertility in the latter half of 1938 and 1939.

Roemer and the First Determination of the Velocity of Light

By I. Bernard Cohen. (History of Science Series, No. 1.) Pp. 64. (New York: Burndy Library, Inc., 1944.) 1 dollar.

AT a time when it was generally believed that light was propagated instantaneously, Roemer's observations on the first satellite of Jupiter convinced most contemporary men of science that the velocity of light was finite. Mr. Cohen surveys the earlier views on the subject, and describes the immediate background of Roemer's discovery. The reception accorded to the work is given in some detail. Roemer's paper in the *Journal des Scavans* (1676), and its English translation in the *Philosophical Transactions* (1677), are reproduced in facsimile, together with a holograph manuscript of some of his observations, from which it is shown how he must have arrived at the high value of 22 minutes for the time taken by light to traverse the diameter of the earth's orbit. The last chapter gives a brief outline of Roemer's distinguished and varied later career, both as public official and as man of science.

This short but valuable study of Roemer first appeared in *Isis*, No. 84, April 1940, published in invaded Belgium. It was reprinted in the United States from one of the few surviving copies in September 1944, on the three hundredth anniversary of Roemer's birth. It will be welcomed as a concise and scholarly appreciation of a man who, though generally remembered only for a single important contribution to science, was one of the outstanding figures of his age.

G. R. NOAKES.

Les éléments de la chimie

Par Georges Champetier. (Bibliothèque d'éducation par la science.) Pp. vi+598. (Paris: Albin Michel, 1943.) n.p.

THIS short treatise on theoretical and physical chemistry is marked by a clear and readable style and by a judicious choice of subjects. The introductory chapters contain an unusually careful exposition of the concepts of chemical species, mixture, compound and element. The determination of atomic weight follows that of molecular weight, and many similar examples of logical sequence are found in the book, which is conceived and executed in a philosophical spirit. Many quite difficult subjects are treated in a simple yet adequate manner, such as band spectra, bond formation, and nuclear physics and chemistry. The modern aspects are dealt with, but the fundamental subjects such as thermodynamics, electrochemistry and phase rule also receive adequate treatment. The whole forms an introduction to modern physical and theoretical chemistry which is both satisfying and interesting, and is in the best traditions of French scientific literature. There is no index, but a full table of contents. The paper and printing are good, and the binding attractive but rather weak.

Modern Bird Study

By Ludlow Griscom. Pp. xi+190+15 plates. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1945.) 14*s*. net.

LUDLOW GRISCOM is the chairman of the National Audubon Society of America and writes with a competence founded on thirty-seven years of experience in the field. His present book is the outgrowth of a series of eight lectures which were given at the Lowell Institute in January 1944, and can be clearly divided into two sections. The first half deals with the capacity, intelligence and adaptability of birds, as well as the general problem of migration, and would be intelligible to any ornithologist and/or bird-lover familiar with the English language. The second half deals with avian distribution throughout the Americas. One is impressed by Mr. Griscom's interest in and enthusiasm for his subject, but his work would command greater respect if, on occasion, his inductive powers had been used with the same force as his deductive.

THE ADVENT OF THE AIRCRAFT GAS TURBINE*

By Air Commodore F. WHITTLE, C.B.E.

International Standard Atmosphere

THE properties of what is known as the "International Standard Atmosphere" for the temperate zone are shown in Fig. 1. At 20,000 ft. the density is a little more than half its sea-level value, and at 40,000 ft. it is just under one-quarter. The temperature drops almost 2° per 1,000 ft. up to just over 36,000 ft. and then it remains constant. A curve for pressure variation is not included but it is very similar to that for density, though the density does not fall off quite so rapidly as pressure because of the reduction in temperature. In the stratosphere, that is, above 36,000 ft., the temperature being constant, pressure is proportional to density. The reduction of temperature with height is of great importance from the gas turbine point of view. As I shall explain later, the lower the temperature the greater the efficiency for given maximum combustion temperatures.

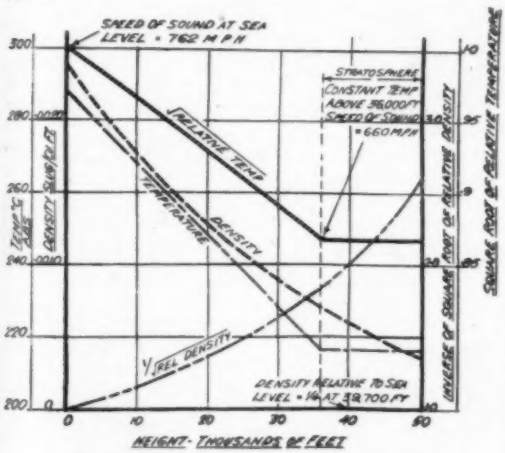
SPEED OF SOUND AT SEA LEVEL = 762 M P H
STRATOSPHERE CONSTANT TEMP ABOVE 36,000 FT
SPEED OF SOUND = 660 M P H
RELATIVE TEMPERATURE
DENSITY
√REL DENSITY
DENSITY RELATIVE TO SEA LEVEL = 1/4 AT 39,700 FT
HEIGHT - THOUSANDS OF FEET
TEMP °C
DENSITY SLUGS/CU FT
INVERSE OF SQUARE ROOT OF RELATIVE DENSITY
SQUARE ROOT OF RELATIVE TEMPERATURE

Fig. 1. International Standard Atmosphere.

The reduction of temperature is also important because of its effect on the speed of sound. The curve showing the relation between the square root of the relative temperature and height corresponds to the change of the speed of sound with height because the speed of sound is proportional to the square root of the absolute temperature. At sea-level it is 762 m.p.h. and at 36,000 ft. and upwards it is 660 m.p.h. As is now well known, when an aeroplane reaches speeds approaching that of sound there is a sharp rise in drag coefficient due to the effects of compressibility. Similarly, there is apt to be trouble with engine parts moving at high speed when the relative velocities approach the speed of sound.

The curve showing the variation of the inverse of the square root of relative density gives the ratio of true air speed to indicated air speed at any height. The air-speed indicator is really a differential pressure gauge which is responsive to the dynamic pressure due to forward speed; but the dial is graduated to give speed readings in accordance with the relationship which holds good between speed and dynamic pressure at sea-level. All the forces on the aeroplane such as drag and lift are functions of dynamic pressure. If the instrument indicates (say) 300 m.p.h., then it means that the dynamic pressure is that corresponding to 300 m.p.h. at sea-level, but at heights above sea-level the true speed is greater than the indicated speed. Thus, if the air-speed indicator records 250 m.p.h. at a height when the relative density is one-quarter, then the true air speed is 500 m.p.h., but the lift and drag forces, etc., are those corresponding to 250 m.p.h. at sea-level. This relationship holds good so long as the true speed is not high enough for compressibility effects to be important.

* From a Royal Institution discourse delivered on December 7.

Drag

The resistance or drag of an aeroplane has two primary constituents. One, known as the induced drag, is the penalty paid for lift; it would be zero with a wing of infinite span. It varies inversely as the dynamic pressure. At high indicated air speeds it becomes very small. The other major component of drag is known as profile drag. By this is usually meant the sum of skin friction drag and form drag. It is approximately proportional to the dynamic pressure up to speeds at which compressibility effects begin to become pronounced and then it increases much more rapidly. Since dynamic pressure is proportional to the square of the indicated air speed, part of the drag varies inversely as the square of the indicated speed and the other part varies directly as the square of the indicated speed; and it can easily be shown that total drag is a minimum when the two components of drag are equal.

At the speed of minimum drag the least work has to be done in covering a given distance, so that it is obviously the speed of maximum range assuming a given efficiency of propelling power plant. At or near sea-level, the speed of minimum drag is not very much greater than the landing speed; but though the drag is a minimum at a given indicated air speed at all heights, it can correspond to very high true speeds at great heights. Thus, if the drag of an aeroplane were a minimum of 1,000 lb. at 150 m.p.h. at sea-level, it would be the same minimum of 1,000 lb. at an indicated air speed of 150 m.p.h. at all heights, but at (say) 40,000 ft. the corresponding true speed would be 302 m.p.h. Note that the minimum work which has to be done in covering a given distance is unchanged by height; that is, for constant efficiency of power plant, height does not allow an increase of maximum range. Note also that in the example given, just over twice as much power would be required for the speed of minimum drag at 40,000 ft. as compared with the sea-level case; against that, of course, the distance is covered in half the time.

Piston Engine/Propeller Combination

In the familiar piston engine and propeller combination, the propeller is essentially a device for inducing an increase of rearward momentum in a stream of air; in other words, it is a form of jet propulsion.

The efficiency of a propeller has two main components, namely, the fan efficiency and the Froude efficiency. Its fan efficiency is its efficiency as a device for turning the shaft power supplied to it into an increase of kinetic energy in a sternwards direction. This fan efficiency is usually more than 90 per cent, so long as the speed of the propeller tips is not too near the speed of sound. One of the obvious losses is the

rotational component of the slipstream, which contributes nothing to the propulsive thrust.

The thrust is proportional to the rate of change of momentum induced in the axial direction. The rate of doing useful work in propulsion is the product of thrust and the speed of the aircraft; this is always less than the energy expended in generating sternwards kinetic energy in the air engaged by the propeller. The ratio of the rate of doing useful work to the rate of generation of increased sternwards kinetic energy is the Froude efficiency. It can easily be shown that for high Froude efficiency it is better to obtain a given thrust by inducing a small increase of velocity in a large mass of air than by inducing a large increase of velocity in a small mass of air; in fact, the formula for Froude efficiency is given by $\frac{2}{r+1}$, where r is the ratio of jet velocity to forward velocity.

Of course, the velocity of portions of the propeller blade relative to the air is greater than the forward speed of the aeroplane because of the rotation of the propeller; so that at high forward speeds we run into compressibility troubles because the rotational velocity at the tip is itself of the order of the speed of sound. For this reason there is a severe fall-off in propeller efficiency at high forward speeds.

With tractor propellers, a factor which has to be borne in mind is that the drag of the aeroplane swept by the slipstream is increased, partly because of the increased velocity and partly because the disturbance in the slipstream causes an early transition in the boundary layer from a low-drag laminar layer to a high-drag turbulent layer. The increase of drag due to slipstream would be much reduced by the use of pusher propellers; and no doubt when certain of the mechanical difficulties attached to the use of pusher propellers have been overcome they will become much more in evidence than they are at present.

Power-Plant Weight and Fuel Consumption

A very important point is illustrated in Fig. 2, namely, that a large proportion of the aeroplane is there to carry the power plant and fuel. Comparisons between different kinds of power plant are often made on the basis of thermal efficiency or fuel consumption per unit power, etc.; but in an aeroplane this is a totally false basis of comparison. It is easily possible that for aeroplanes to perform certain tasks the fuel consumption expressed in terms of power for one power plant may be substantially higher than another, and yet because the apparently less efficient power plant may make an altogether smaller aeroplane possible for the given duty, it may be more efficient when the fuel consumption is measured in terms of ton-miles of useful payload.

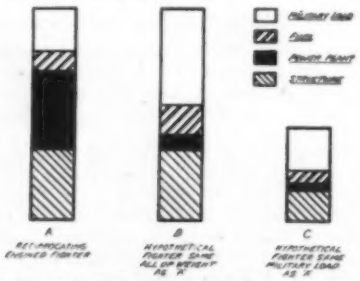

Fig. 2. WEIGHT DISTRIBUTION OF FIGHTERS (SAME SPEED AND ENDURANCE).

At *A* is illustrated the approximate weight distribution of a modern fighter with petrol engine and propeller. The military load including pilot is 20 per cent, the power plant and fuel accounts for 47 per cent —37 per cent to the power plant and 10 per cent to the fuel. Structure weight represents 33 per cent. But of course part of the structure weight is debitable to power plant and fuel, so that some 70 per cent of the total weight is directly or indirectly attributable to power plant.

Diagram *B* illustrates the weight distribution of a hypothetical aeroplane for the same speed and endurance at the same height, having a hypothetical power plant which consumes about 50 per cent more fuel in proportion to power, but which is only one-fifth the weight in proportion to power. In the second case the amount of fuel is 50 per cent greater than in the first, but the military load is 127 per cent greater. *C* shows the reduction in size we get if we make our hypothetical aeroplane to carry the same military load. In the second case the payload/fuel ratio is about 50 per cent better than the first. A short-range aeroplane of high performance illustrates this point. For greater ranges things move in favour of the heavier power plant with the lower fuel consumption; but I hope I have made it clear that a comparison between two power plants should not be made without reference to the duty which the aeroplane has to perform.

Campini System

The Campini system of propulsion consists of an internal combustion engine driving a low-lift compressor within a large diameter duct, either in a fuselage or a nacelle. The function of the low-lift compressor (or 'ducted fan' as it is often called) is the same as a propeller, namely, to impart increased kinetic energy in a rearwards direction.

The Italians claim to have flown with this system in 1940, but the results were so disappointing that the scheme was dropped. It is difficult to see why they ever thought it worth while, because nothing is saved in power-plant weight as compared with the normal piston engine and propeller combination, while the mass of air which the fan can engage is so much lower than that of a propeller that the Froude efficiency is inevitably very much lower. The most that can be claimed in favour of it is an absence of slipstream over the external surfaces, shorter undercarriage, etc., and that the heat from the engine exhaust, etc., which would otherwise be wasted can be recovered to a small extent because it is discharged into air at a pressure a little above atmospheric.

The Impulse Duct

The propulsive system of the flying bomb is what is known as an impulse duct and is extremely simple. In front of the duct there is a grid of automatic leaf-spring flap valves. Petrol is injected into the duct immediately behind these valves and a series of explosions takes place at a frequency depending on the dimensions of the duct. As the pressure in the duct drops below the ram pressure the leaf springs open and admit a fresh charge of air and are closed again by the succeeding explosion. Propulsion is thus in effect produced by a series of backfires. In common with the propeller, the Campini system, and the turbo-jet system to be described below, the device produces a thrust because it takes air in at the front and expels it to the rear with increased velocity. The thrust, of course, fluctuates considerably.

The fuel consumption is very high, though power-plant weight is very small. For the purpose for which it was designed, namely, the pilotless bombing of a very large area at a range of the order of 150 miles, nobody can deny that it was very effective.

The ME. 163 (Bi-Fuel Rocket System)

The bi-fuel rocket system was developed intensively by the Germans, as in the Me. 163 interceptor fighter. Both the fuel and the oxygen required for combustion have to be carried in the aeroplane, consequently the amount of expendable material which has to be carried for a flight of even short duration is very great. This system differs from others in that it does not draw in air from the atmosphere. In the devices propelled in this way, the Germans used hydrocarbon fuel and either liquid oxygen or a substance rich in oxygen such as hydrogen peroxide or nitric acid. The thrust per unit mass flow of the bi-fuel rocket system varies, of course, with the fuel constituents, but is usually between 160 and 200 lb./lb./sec. This system of propulsion can give very high performance for a very short time.

The Turbo-Jet System

The turbo-jet system of propulsion (Fig. 3) brings us to the gas turbine. Air is taken in at the front and compressed into a combustion chamber by a compressor. In the combustion chamber it is heated at constant pressure. It then expands through a turbine to an extent sufficient to drive the compressor. Final expansion then takes place through the propelling nozzle. It works on the constant-pressure cycle illustrated in the pressure-volume diagram shown (Fig. 4). *A*—*B* represents the compression due to ram pressure, *B*—*C* the further compression in the compressor, *C*—*D* the combustion at constant pressure, *D*—*E* that portion of the expansion through the turbine necessary to drive the compressor, *E*—*F* the final expansion which provides the kinetic energy of the propelling jet.

About 1920–30 the many failures in attempts to produce a successful gas turbine had led to a general pessimism in the engineering world. There was a curious tendency to believe that materials of sufficiently high stress-temperature properties would not become available, and that the comparatively low efficiencies of compressors and turbines of that time were inevitable. I believed, on the other hand, that very considerable improvements in component efficiencies were possible, and in the case of the jet propulsion gas turbine I realized that there were certain favourable factors not present in other applications, namely :

(1) The low temperature of high altitudes made possible higher efficiencies for a given maximum cycle temperature and given component efficiencies.

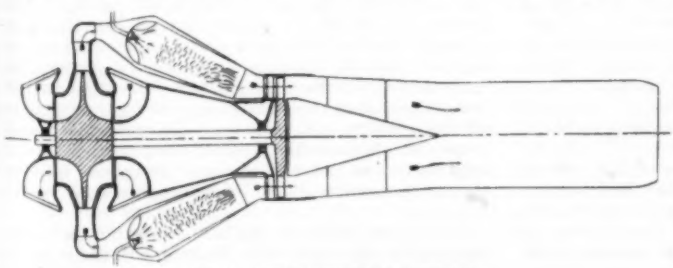

Fig. 3. JET PROPULSION GAS TURBINE.

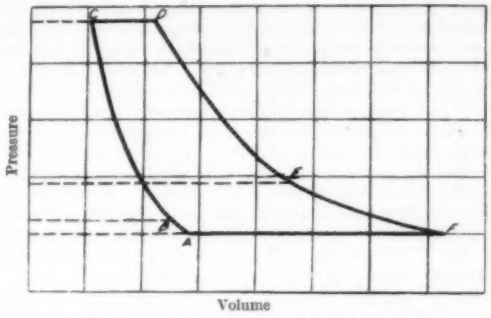

Fig. 4. CYCLE AT 500 M.P.H. AT SEA-LEVEL.

(2) Part of the compression could be obtained by the ram effect of forward speed at high efficiency, thereby raising the average efficiency of the whole compression process.

(3) Only sufficient of the expansion took place in the turbine as was necessary to drive the compressor, and therefore only a part of the expansion was subject to turbine losses.

I have already told the story of the early days of the Whittle jet propulsion gas turbine in my James Clayton Lecture before the Institution of Mechanical Engineers, so I will not go into the details now. We started to construct our first experimental engine in 1936 and first ran it in April 1937. As first constructed, it was very unsatisfactory, and we decided to reconstruct, and the second edition was running in April 1938. After severe damage as the result of a turbine failure we decided to reconstruct once more and we had the third edition on test in October 1938. The compressor was a single-stage double-sided centrifugal. It was directly coupled to a single-stage turbine. The air from the compressor was delivered to ten combustion chambers in parallel and the hot products of combustion passed from the combustion chambers through the turbine and out through the jet pipe and propelling nozzle.

In those days we used a 10 h.p. B.S.A. motor-car engine for starting, but later on we found that it was possible to use a small electric motor. We did in fact succeed in starting up with the starter-motor off the starting engine.

That engine was the parent of a whole family of jet propulsion gas turbines. A flight engine, known as the WI, aerodynamically and thermodynamically similar to the experimental engine, was made. At the same time the Gloster Aircraft Co. made the experimental aeroplane known as the E28/39. Successful flight tests with the WI installed in the E28/39 took place in May 1941.

The Rolls-Royce Derwent V

The Rolls-Royce 'Derwent V' is the engine with which the world's speed record was recently gained. The effective thrust power of each engine when travelling at 600 miles an hour was of the order of 5,000, that is, the total effective thrust horse-power of the two engines was about 10,000. For the ordinary reciprocating engine and propeller combination to have produced the same thrust power, the effective

total shaft power would have to have been about 16,700 h.p., for which the fully installed weight would have been of the order of 30,000 lb., that is, about twice the weight of the aeroplane. The fully installed weight of the two 'Derwent V's' would be less than 3,000 lb., that is, less than 10 per cent of the weight of the conventional power plant, to produce the same effective thrust power. I admit that I have made this weight comparison under conditions least favourable to the conventional power plant, because the power of the latter can be maintained by supercharging to heights of the order of 30,000 ft., whereas the power of the turbo-jet engine falls off with height. Comparisons made at lower speeds would also have been much less favourable to the jet engine, but at least these figures serve to illustrate the point that there is little hope of the conventional power plant competing with the turbo-jet at very high speeds.

The power required to drive the compressor of the Derwent V would be of the order of 120 h.p. per lb. of air flowing through the engine per second. The mass flow would be of the order of 80 lb./sec., so that the shaft power produced by the turbine is in the neighbourhood of 10,000. The kinetic energy in the jet is also of the order of 10,000 h.p.

Materials

A very important phase in the successful development of aircraft gas turbines has been the evolution of materials capable of withstanding a combination of high stress and high temperature. The lack of such materials in the past was one of the principal obstacles to early experimenters. To some extent a vicious circle was operating. There was little incentive to produce materials which would make gas turbines practicable so long as gas turbines did not exist ; and the non-existence of the materials hindered the evolution of the gas turbine. Fortunately, in the last two decades there have been other stimuli to the development of such materials, one of the chief of these being the need for them in the exhaust valves of piston engines, etc. Another was the need arising out of the use of increasing temperatures and stresses in steam turbines. When we started practical work in 1936, the best material available was Firth-Vickers 'Stayblade'. We used this material for our first turbine disks and blades ; it was a ferrous alloy of austenitic type having a high nickel and chromium content. Shortly after, Firth-Vickers produced a much improved austenitic steel of the same class known as 'Rex 78', and the use of this material for the turbine blades led to important improvements in performance. Then the Mond Nickel Co. produced a nickel chromium alloy known as 'Nimonic 80', and this has been extensively used recently.

In turbine design we are not so much concerned with the ultimate strength of materials at the working temperatures as with the creep properties. Under stress at high temperatures, all these materials slowly extend ; this is the process known as 'creep'. For a given stress and temperature there is usually a fairly well-defined rate of creep. The order of creep-rate which is tolerable in an aircraft gas turbine is about 1 per cent per 1,000 hours.

The improvement in the properties of light alloys, especially aluminium alloys, has also had an important influence on gas turbine development, though properties of light alloys have been by no means as limiting as those of turbine blade materials.

Efficiency of the Turbo Jet Engine

I have shown earlier that Froude efficiency is very dependent on the ratio of jet speed to forward speed. With these jet engines the jet velocities are of the order of 1,600 to more than 2,000 ft. per sec., that is, of the order of three times the forward speed of the aeroplane. Froude efficiency corresponding to a 3 : 1 ratio is 50 per cent, so that the propulsive efficiency is relatively poor, though at speeds of the order of 500 m.p.h. the efficiencies of propellers are dropping to values little more than this. The efficiency of the engine as a heat engine for generating kinetic energy in a jet is about 34 per cent at heights where the temperature is very low, so that the absolute overall efficiency is of the order of 17 per cent.

The absolute efficiency of the piston engine and propeller combination is about 24 per cent at cruising power and moderate speeds, but at high speeds where the peak power has to be obtained by a large degree of supercharging and rich mixtures, and where compressibility effects have reduced the propeller efficiency very considerably, the piston engine and propeller combination shows little if any improvement on the jet engine. The jet engine is only a small fraction of the weight of the piston engine and propeller combination, and this, coupled with the fact that a jet aeroplane is intrinsically smaller and cleaner aerodynamically than the more orthodox type, throws the balance heavily in favour of the jet engine for high-performance aircraft such as interceptor fighters and high-altitude mailplanes of moderate range. Anything which is done to reduce aircraft drag brings the turbo-jet system more and more on to the map.

Variation of Power with Height and Speed

If the air temperature remained constant at all heights, the thrust power of the turbo-jet would be exactly proportional to air density at a given speed ; but owing to the increase of efficiency with lower air temperatures, the power for a given speed falls off less rapidly than the density up to the stratosphere. In the stratosphere the temperature is constant and power is therefore proportional to density. The power required for the aeroplane for level flight at a given speed of course falls off, at least until that given speed corresponds to the speed of minimum drag.

With the piston engine and propeller, the thrust falls off rapidly with forward speed in such a way that the effective thrust-power shows only a small variation over a wide speed-range. The turbo jet, on the other hand, gives only a small variation of thrust, and hence the effective thrust-power is nearly proportional to speed.

Gas Turbine/Propeller Combination

So far the gas turbine has found its main application in aircraft in the ways I have already indicated ; but that is not its only use. The turbo-jet system is essentially suitable for high-speed aircraft to cover moderate ranges at heights of the order of 40,000 ft. For lower speeds at lower heights and longer range, there is no doubt that the gas turbine will be used to drive a propeller, thus combining the high propulsive efficiency of the propeller with the very low plant-weight of the gas turbine. With arrangements of this kind there will usually be some jet thrust, but the greater proportion of the power would be fed to the propeller.

This by no means exhausts the possibilities of gas turbines for use in aircraft. For some duties it seems possible that it would be better to use a gas turbine

driving a ducted fan, rather on the lines of the Campini system mentioned earlier, though with the piston engine of the Campini system replaced by a gas turbine.

The permutations and combinations possible in gas turbine power plant are endless. The variations possible with the piston engine are limited by the fact that the processes of compression, combustion and expansion take place in the one organ, the cylinder, but in the gas turbine these three processes are carried out in specialized organs. For compression, we can use centrifugal compressors or axial flow compressors, and possibly displacement compressors or various combinations of these. There is a corresponding possible number of variations in the combustion system, and again a large number of variations is possible in the turbine system. Added to all these are the possibilities involved in the use of heat exchangers, the burning of additional fuel between turbine stages, or in the low-pressure air from a ducted fan, and so on. We are as yet only at the very beginning of this field of engineering.

So far it has been the British and American practice to use kerosene as the fuel. It is quite possible to use lower grade fuels so far as the engine is concerned, but they usually have a freezing point in the neighbourhood of 0–10° C.—an inconvenient property for aircraft which have to be left standing on an airfield in exposed weather conditions. Nevertheless, no doubt lower grade fuels will become more generally used in future.

One great advantage that turbine engines have over normal power plants is almost complete absence of vibration and much reduced noise. These are more important factors than is generally realized. For commercial purposes it will add greatly to passenger comfort. The gain on this account will not be so great with the propeller gas-turbine combination as with the simple jet or ducted fan types. This may be a factor operating strongly in favour of the ducted fan when there is otherwise little to choose between them.

Conclusions

There is no doubt that the aircraft gas turbine is going to have profound effects on future aircraft development. I predict that in from five to ten years' time we shall see the piston engine displaced in all new aircraft except the light aeroplane. It is possible that the gas turbine will invade that field also; but at present it seems less easy to design for the low power required by light aeroplanes than for much higher power than we are using at present. When I say that the gas turbine will displace the reciprocating engine, I do not mean that it will be substituted for the reciprocating engine in types designed for the latter—in fact that is very unlikely, because, among other things, the use of the gas-turbine type of power plant introduces an important new aspect in the aeroplane/engine combination. Power plant and aircraft will have to be designed together. Hitherto it has been the practice to treat them almost independently, but in future one will need to be 'tailor-made' to the other. There will also be much greater variation in types of power plant, depending on the duty the aeroplane has to perform. In fact, the task for which the aeroplane is intended will have to be the starting point for both the engine and the air-frame design.

Another important change of procedure will be required. In the past, it has been the custom to design and develop an engine virtually independently of any particular aircraft, and in advance of the design of the aeroplanes which eventually used them. The usual development time for reciprocating engines was about five years. The corresponding time for gas turbines is much shorter. The Derwent V, for example, was designed and built and gave its full design power within four and a half months. Other firms have achieved similar results in about six months. So not only will the power plant and aircraft have to be made as a unified whole, but also design and development must proceed in parallel if years are not to be lost.

AMINO-SUGARS AND URONIC ACIDS IN NATURE

THE meetings organised periodically by the Biochemical Society, at which experts in a chosen field present short contributions designed as an introduction to a general discussion of the selected subject, have proved both popular and useful. The discussion held on February 16 on amino-sugars and uronic acids in Nature was no exception, bringing together as it did those interested in the more purely chemical problems of the constitution of the polysaccharides and those for whom the biological role of these most widely distributed substances is of primary interest.

The morning session, under the chairmanship of Prof. E. L. Hirst, was opened by Prof. Gunnar Blix of Uppsala, from whose laboratory much of our knowledge concerning these substances has emanated. Prof. Blix emphasized the wide distribution of the hexosamines and uronic acids in living structures and suggested that such ubiquity would alone suggest that they fulfil a role of importance. The long-chain polymers containing polysaccharide acids function in many situations as supporting or protecting gels. The newly shed ovum is surrounded by hyaluronic acid, the hydrolysis of which by the hyaluronidase of spermatozoa may be an important preliminary to fertilization. Hyaluronic acid and chondroitin sulphuric acid also function as cementing materials in the connective tissues, and alterations in these components have been found to be associated with pathological states. The invasiveness of pathogenic micro-organisms appears to be intimately connected with their production of the enzyme hyaluronidase. By reason of the high viscosity of solutions of the undegraded polysaccharide acid polymers, these substances are very suitable as biological lubricants and occur in synovial fluids. The interesting possibility that the pathological changes seen in infectious rheumatic disease and the hyaluronidase of the microbial invaders may be causally related is still an unanswered question, but clearly one of no little importance.

That the surfaces of mucous membranes may derive protection, particularly from proteolytic enzymes, by the mucoitin sulphuric acid and other mucins characteristically present in their secretions is an attractive hypothesis full of possibilities both in relation to normal physiology and to pathological changes. The method by which the polysaccharide sulphuric esters may be revealed histochemically was discussed by Prof. Blix, who pointed out the association of these materials with the process of growth in different tissues.

The neutral polysaccharides frequently occur in chemical combination with proteins, as, for example,

in the globulins of blood serum. The α and β globulin fractions are particularly rich in such carbohydrates, and variations in their level have been recorded in certain pathological conditions. Other members of this group are endowed with highly specialized functions as seen, for example, in the gonadotrophic hormones, the enzyme choline esterase and serologically important blood group antigens. Chitin may also be mentioned as a neutral polysaccharide, physically somewhat similar to cellulose and subserving a comparable physiological role. Prof. Blix pointed out that the problems of the biosynthesis of the polysaccharides are as yet largely untouched, and that numerous possibilities remain for development both in the purely physiological and also pathological spheres in connexion with these compounds.

Dr. E. G. V. Percival discussed that group of carbohydrate materials termed polyuronides, in which, strictly speaking, the polysaccharide is made up entirely of uronic acid residues. Many of these substances are familiar and widely distributed constituents of vegetable materials. The pectins, for example, although varying widely in physical properties according to their origin, appear to be constructed essentially of pectic acid, a polymer of *d*-galactopyruronic acid units mutually united by 1 : 4-α-linkages with which may be associated arabans and galactans. In alginic acid the chain is composed of *d*-mannopyruronic acid residues and union is by 1 : 4-β-linkages.

The specific polysaccharides elaborated by *Pneumococcus* types III and VIII have also been shown to be polyuronides, the cellobiuronic acid residues differing, however, in the proportion of glucose to glucuronic acid which they contain. Less is known about the constitution of other capsular polysaccharides such as those of *Pneumococcus* types I and II, *V. cholerœ*, *Rhizobium radicicolum*, etc., but cellobiuronic acid is concerned in their structure. Oxycelluloses prepared by the oxidation of cellulose with nitrogen dioxide have been shown to bear some relation to the types III and VIII specific polysaccharides by means of their precipitin reactions.

Turning next to the class of polyuronides termed hemicelluloses, Dr. Percival pointed out that structural knowledge in this difficult and complex group is almost non-existent, largely owing to the difficulty of isolating homogeneous products. An investigation of the methylated glucoses obtained by the hydrolysis of a methylated hemicellulose fraction of Iceland moss has revealed the existence of glucose residues linked through the 1 : 3, 1 : 4, 1 : 6 and also the hitherto unreported 1 : 2 positions. Mannose, galactose and glucuronic acid were also detected among the products of hydrolysis of these materials. The mucilaginous polysaccharides of plant seeds are also highly complex structures, that of *Plantago lanceolata* seeds possessing a highly branched structure ; much further work remains to be done on the members of this group.

The most precise information about complex polyuronides has resulted from the studies of F. Smith on gum arabic and of E. L. Hirst on other plant gums. These substances have a relatively resistant core in which glucuronic acid is incorporated with other sugar residues, for example, in gum arabic, galactopyranose, in damson gum, galactopyranose and mannopyranose. Attached to this core are other sugar residues easily removed by auto-hydrolysis, and formulations have been made suggesting the structure of polyuronides of this type. Gum tragacanth is even more complex, the tragacanthic acid portion containing *d*-galacturonic acid units united as in pectic acid ; end groups of *d*-xylopyranose and *l*-fucopyranose are present as well as xylopyranose units linked through the 1 : 2 positions. This gum also contains a neutral polysaccharide as well as a fraction which is steroid in nature.

The mode of linkage of the amino-sugars in their naturally occurring derivatives was discussed by Dr. M. Stacey. Only two of the many possible hexosamines have been found in Nature, namely, chitosamine (*d*-glucosamine or 2-amino-*d*-glucopyranose) and chondrosamine (2-amino-*d*-galactopyranose), and the precise configuration of these has been settled. The amino-sugars occur widely in polymeric form as protein carbohydrate complexes in body tissues and fluids, in chitin which forms the protective covering of Crustacea, and in the protoplasm of micro-organisms. The amino-sugars may be associated with hexoses only, as in the blood group substances, or occur in compounds with hexuronic acid, as in heparin and hyaluronic acid. These amino-groups are always substituted by acetyl or other residues and do not engage in polymeric linkage, except possibly in the heparin molecule.

The classification of the protein carbohydrate complexes was dealt with at some length by Dr. Stacey, after which he considered in detail the structure revealed in his own laboratory of the carbohydrate residue of ovomucoid, a mucoprotein from egg-white. The evidence presented indicates a central core of three mannose units to which are attached by glycosidic linkage seven N-acetyl glucosamine units and one galactose unit. It is considered that this unique hendecasaccharide is not a repeating unit but a whole molecule, to the glucosamine units of which are attached peptide chains thereby constituting a mucoprotein. It was suggested that serum mucoid and possibly the gonadotrophic hormones may be similarly constituted.

A relatively stable carbohydrate residue of the blood group A substance had been shown to be built up from *d*-mannose, *d*-galactose, *l*-fucose and *d*-glucosamine units. There is as yet no precise knowledge regarding the mode of linkage of any of the units in complexes such as heparin and mucoitin sulphate. One interesting problem in the group concerns the N-acetyl residues, both from the chemical aspect in regard to their power of stabilizing glycosidic linkages, and also in regard to their significance in immunity reactions.

The afternoon session, under the chairmanship of Prof. A. R. Todd, commenced with a paper by Dr. A. Pirie on "Mucoitin Sulphuric Acid, Chondroitin Sulphuric Acid, Hyaluronic Acid and Heparin". The development of knowledge concerning these substances was summarized and the methods available for their isolation and structural investigation. The state of the acid mucopolysaccharides in the tissues can be judged to some extent by the means necessary to extract them and free them from proteins.

Thus, hyaluronic acid may be extracted with water, chondroitin sulphuric and mucoitin sulphuric acids only by solutions of salts or alkalis. Unfortunately, depolymerization is readily induced by such reagents, and the product is often obtained in a degraded form. Hyaluronic acid is also subject to degradation in the presence of oxygen or oxidizing systems such as ascorbic acid and copper, and Blix has shown that much more satisfactory preparations are obtained by working in an atmosphere of nitrogen.

The glycoproteins were dealt with by Prof. C. Rimington, who defined these substances as proteins which contain carbohydrate groups in chemical combination as an integral portion of the molecule. According to the classification of Blix, acidoglycoproteins and neutroglycoproteins may be distinguished. Confining attention to the latter class, Prof. Rimington pointed out that by the methods ordinarily employed for the preparation of proteins, it is very difficult to get rid of carbohydrate impurities and that all possible criteria of purity should be applied to any preparation before it is concluded that it is, in fact, a glycoprotein. Five criteria of general applicability were listed, namely, (1) constancy of composition, (2) electrophoretic homogeneity, (3) ultracentrifugal homogeneity, (4) independence of solubility upon the amount of solid phase, and (5) constant potency in the case of materials exerting a measurable physiological effect; a number of glycoproteins for which recognition has been claimed were then examined in the light of their conformity to these criteria.

The presence of a polysaccharide in serum albumin was first demonstrated by Rimington, but Sørensen in his classical work on this protein showed that it does not obey criterion (4), a whole series of crystalline albumins being obtainable which differ in their solubilities and in their carbohydrate contents. McMeekin has claimed the isolation of crystalline serum albumin containing 5·5 per cent carbohydrate, which he considered was a single substance since it was apparently homogeneous both in the ultracentrifuge and in the electrophoresis apparatus. The further test of constant solubility was not applied, however, and in view of the behaviour of the serum gonadotrophin, this final criterion would seem necessary.

Much careful work has been done upon the protein hormones of the anterior lobe of the pituitary gland, and these substances are among the best characterized of protein preparations. The luteinizing gonadotrophin or metakentrin has been obtained in a form satisfying all available criteria of purity and containing 4·5 per cent of carbohydrate (from sheep glands); it is thus a well-authenticated glycoprotein.

The gonadotrophin of pregnant mares' serum has not yet been obtained in such a satisfactory condition; Rimington and Rowlands found material with an activity of 3,500 I.U./mgm. to be electrophoretically and ultracentrifugally homogeneous, but further fractionation with acid alcohol raised the potency to 12,500 I.U./mgm. without at the same time appreciably altering the carbohydrate content. It seems quite clear that one must here be dealing with a mixture or mutually reacting system of very closely related glycoproteins only some of which possess gonadotrophic activity, and this experience prompts a warning against accepting as homogeneous any glycoprotein (especially if derived from serum) which has not satisfied all criteria of purity which can be applied to it.

Dr. W. T. J. Morgan reviewed our chemical knowledge of the blood group substances and pointed out that the polysaccharide components of the *A*, *B* and *O* agglutinogens are similar if not identical, so that differences must be in the polypeptide part of the molecule. Besides N-acetylglucosamine and *d*-galactose, they are said to contain *l*-fucose and *d*-mannose.

A very interesting reaction occurs when these glycoproteins are heated at 100° for 3–4 min. in very dilute alkali; a portion of the N-acetylglucosamine residues becomes detached and dialysable and in the alkaline medium, through ring closure between the aldehyde and N-acetyl groups, oxazole or oxazoline derivatives are formed which give a red colour directly with Ehrlich's reagent. Clearly the mechanism of this reaction is of no little importance for an understanding of the structure of the polysaccharide complex, and lively discussion centred about it. Dr. Morgan considers that the alkali labile linkages are probably glycoside linkages which are associated with C atom 1 of the N-acetylglucosamine residues.

The enzymes attacking amino-sugar and uronic acid polysaccharides were considered by Dr. H. J. Rogers, from whose survey it was clear that a cardinal difficulty in this field has been the separation of individual enzymes from crude extracts. This has been especially noticeable in the case of hyaluronidase, where the end-products produced from hyaluronic acid have been shown to differ according to the source of the enzyme.

In the final communication, Prof. G. F. Marrian described the steroid glucuronides which have so far been isolated from urine, and the methods by which the position of attachment of the uronic acid residue has been deduced. It is noteworthy that crystalline sodium pregnanediol glucuronidate prepared from human pregnancy urine has been found to contain about 15–20 per cent of an impurity believed to be sodium pregnane-3(α)-ol-20-one glucuronidate, but which cannot be removed by the usual methods of purification. Similarly, the sodium salt of pregnane-3(α), 17, 20-triol glucuronidate cannot be separated from sodium pregnane-diol glucuronidate by any of the usual purification procedures.

The possible functions of the enzyme β-glucuronidase were discussed and also the various steps by which the biosyntheses of the glucuronides might be accomplished.

CALCAREOUS CONCRETIONS IN A CAMBRIDGESHIRE STREAM

By Prof. F. E. FRITSCH, F.R.S., and Dr. C. F. A. PANTIN, F.R.S.

DURING the exceptional drought of 1943, the Bourne Brook, a stream which enters the River Cam near Grantchester, was, except for the last mile of its course, without water for the first time for many years. In the lower reaches of the dry bed there were numerous dead *Anodonta cygnea* and small fish. Normally the Bourne consists of long pools, about 8 ft. across and 2 ft. deep with a bottom of mud and clay, joined by shallow runs which in summer are usually filled with aquatic vegetation. The pools, on the other hand, generally contain no higher plants and are often deeply shaded by bushes.

The dry bottom of these pools presented a remarkable sight, being strewn with coral-like nodules 2–20 cm. in diameter (Fig. 1) resting on the mud. These nodules ranged in colour from pale grey-green in damp specimens to a dirty white in dry ones. When broken open each nodule contained a foreign nucleus around which friable calcareous material had evidently been deposited. The nucleus was commonly a pebble, a piece of water-logged wood or a molluscan shell. Anodon shells were found with all stages of the calcareous growth upon them and similar material

Fig. 1.

encrusted a small concrete dam across the river. Fig. 2, which represents a nodule cut across exposing its flint nucleus, shows the layered character of the calcareous growth.

The deposition of the nodules is undoubtedly associated with the presence of blue-green algæ, to which, indeed, the greenish tint of freshly dredged specimens is due. The principal species found in them is *Phormidium incrustatum* (Naeg.) Gom., which is known to be concerned in lime deposition and has not previously been recorded for Britain. The larger growths are raised into many rounded bosses of various sizes and laterally confluent with one another. The outer convex surface of each boss usually shows a series of low curving ridges surrounding shallow angular depressions.

Decalcification of a boss in 1 per cent hydrochloric or acetic acids proceeds slowly for some days. The rather soft gelatinous mass that remains, when all the lime has been removed, is of the same size as the original boss. A longitudinal section shows that a greenish tint is only present in the relatively tough surface layer, which is about 1–1·5 mm. thick. The whole interior appears white and rather crumbly. The colourless mucilage, which envelops the numerous *Phormidium* filaments and forms the basis of the gelatinous growth, contains a good deal of incorporated silt. In the greenish surface layer, the sheaths of the densely packed *Phormidium* filaments are largely occupied by trichomes, while in the interior of the decalcified mass for the most part only empty sheaths are found. The relatively small number of these sheaths in the interior suggests that some may have already undergone decay. In the outer living part most of the filaments are arranged approximately parallel to one another and at right angles to the surface. Abundant hormogone formation takes place from the outer ends of the filaments. Buried in the stratum are diverse foreign bodies (fragments of coniferous wood, spiral vessels, threads of *Œdogonium*, etc.), as well as occasional small growths of other blue-green algæ, some of them retaining their vivid blue colour.

Fig. 2.

If one of the bosses is kept in 1 per cent acetic acid for about twenty hours, decalcification only sets in in the surface layer, which can be peeled off the hard remaining portion like a skin. If the outer surface of this skin is viewed from above, one sees projecting filaments of *Phormidium* which probably represent the initiation of a new increment on the surface of the nodule. The edge of the skin presents a striated appearance as a result of the parallel arrangement of the contained trichomes.

The growth on the dam was not so pure, but also consisted to a large extent of calcified *P. incrustatum*, although the stratum was here relatively thin with the filaments of the alga irregularly arranged and densely compacted. This is probably an earlier stage in which the characteristic bossed growths have not yet developed. Intermediate conditions occurred on a shell of Anodon, where some bosses were becoming evident.

The calcified growths also include tufts of a green alga, a species of *Gongrosira*, which in places are quite plentiful, in others altogether lacking. Diverse species of *Gongrosira* are known to occur in streams and some of them deposit lime. The very irregular occurrence of these tufts, however, suggests that they are just growths of *Gongrosira* that have become buried in the *Phormidium*-stratum (like the other foreign bodies mentioned above) and their complete absence in certain parts of the nodules indicates that they are probably not in any way responsible for their formation.

These calcareous growths recall more or less similar concretions found in lakes in various parts of the world[1]; but there is only one previous record of their occurrence in streams. H. J. Roddy[2] describes from the Little Conestoga Stream, Lancaster County, Pa., nodules which in physical characters and mode of occurrence seem to resemble exactly those found in the Bourne.

Dr. D. Stockdale kindly gave us the following analysis for one of the dried Bourne Brook specimens. The values for Little Conestoga specimens are calculated from Roddy's figures.

	Bourne Brook	Little Conestoga
SiO_2	4·75 per cent	12 per cent
SO_3	0·66 ,,	—
P_2O_5	0·15 ,,	—
CaO	48·55 ,,	39–45 ,,
Fe_2O_3	0·94 ,,	3 ,,
Al_2O_3	1·78 ,,	trace ,,
MgO	0·05 ,,	trace to 0·5 ,,
H_2O (at 105° C.)	1·22 ,,	1 ,,
CO_2	37·29 ,,	31–35 ,,
Organic matter	4·46 ,,	1–12 ,,

Roddy found the nodules also in a few neighbouring streams, but only in those with a high content of dissolved salts, presumably calcium carbonate. Cambridgeshire waters are generally rich in calcium carbonate, and nodules similar to those of the Bourne Brook have been found by us in other local streams, such as the Linton River and Hobson's Brook, though not, up to the present, in the River Cam itself. These

other streams rise in the chalk and are therefore heavily impregnated with lime, but curiously enough the nodules are much less developed in them than in the Bourne Brook, which flows over gravels, clays and the greensand, west of the chalk escarpment. This suggests that factors other than lime content of the water may also be important. It is noteworthy that the Bourne Brook is more apt to become fouled with organic matter from agricultural land than the other streams.

The chief apparent difference between the Bourne Brook and Little Conestoga nodules rests in the Algæ recorded from them. Roddy attributes the precipitation of calcium carbonate to a number of blue-green Algæ and records *Gloeocapsa*, *Gloeothece*, *Aphanocapsa*, *Nostoc*, *Oscillatoria* and *Rivularia*, but not *Phormidium*. It would be of interest to know whether, in spite of the physical similarity, the nodules are produced by different genera of Algæ in the only two cases on record.

[1] Fritsch, F. E., "Structure and Reproduction of the Algæ", **2**, 868 (1945).

[2] Roddy, H. J., *Proc. Amer. Phil. Soc.*, **54**, 246 (1915).

OBITUARIES

Prof. J. Lloyd Williams

Emeritus Professor John Lloyd Williams, of Aberystwyth, died on November 15, 1945. A native of Llanrwst, he entered the Normal College, Bangor, to prepare himself for a teaching career. An inveterate reader, a patient observer of Nature and her ways, a true lover of the open air, he was one of a group of distinguished North Wales botanists of his time, and contemporary with Dr. Trow, later professor of botany and principal of University College, Cardiff, and Prof. Phillips, who became professor of botany at Bangor. Soon after leaving college, Dr. Lloyd Williams was appointed master of Garn Dolbenmaen Board School, where in addition to his school duties he pursued his botanical studies and continued to develop the musical talent which made him prominent in eisteddfod circles, both as a choir conductor and an adjudicator.

Eventually Dr. Lloyd Williams returned to Bangor, where he studied in the University College of North Wales, and graduated in the faculty of science in 1906; he was afterwards appointed to a lectureship on the staff of the Botany Department of the College. In those days, the Botany Building at Bangor was almost lapped by the waves; and under Prof. Phillips, Dr. Lloyd Williams' enthusiasm for the study of marine plants became manifest. Later, under Sir John Farmer, Dr. Lloyd Williams continued his investigations at the Imperial College, London, and began his important contributions to the life-history of the brown seaweeds. He was appointed to the chair of botany at Aberystwyth in 1916, where he was ideally placed for the continued study of marine plants. He was honoured by his colleagues by being made president of Section K (Botany) of the British Association at the Southampton meeting in 1925, and he did not resign the chair of botany at Aberystwyth until 1926, when he was seventy-one years of age. Prof. Lloyd Williams was a great teacher and a true naturalist. He endeared himself to his students, and in them his enthusiasm for the subject is reflected. To him, the field of Nature was the great laboratory, and work indoors was a corollary to that primary mode of investigation.

It is not given to many individuals to be specialists in more than one field of study, but Prof. Lloyd Williams had attained that distinction. In 1936, he became an honorary doctor of music of the University in which he already held a D.Sc. degree. He was jointly responsible, with Dr. Mary Davies, for the foundation of the Welsh Folk Song Society, and from its inception he retained the editorship of the *Journal* of that Society. He journeyed throughout Wales to collect the old melodies, and in addition to arranging those for publication, he composed two operettas, one of which, "Llew Tegid", attained great popularity.

During the War, Prof. Lloyd Williams wrote his autobiography, "Atgofion Tri Chwarter Canrif", published by Gwasg Aberystwyth, a work which was very well received. Second and third volumes followed, and at the time of his death he was busily revising proofs of the fourth volume. In these interesting books, Prof. Lloyd Williams recalls the memories of his early days. It was through indomitable courage, ability and high ambition that he was able to pursue the subjects for which he cared. He retained those interests until the close of his long life, and when approaching his ninetieth year, he visited the Cader Idris range to see again some rare plant. Possessed of a wealth of knowledge, a clear voice, a pleasant smile and ready wit, Prof. Lloyd Williams endeared himself to those with whom he came in contact. His influence in his department and in Wales remains, though with his passing we have lost a great and distinguished son of the Principality.

Lily Newton.

Dr. J. C. Mottram

J. C. Mottram was born at Holt, Norfolk, in 1880 and educated at The Beacon, Sevenoaks. He entered University College, London, in 1898, and five years later graduated in medicine. After a period of post-graduate study at Cambridge he took the D.P.H. in 1906. In the Cancer Research Laboratories of the Middlesex Hospital he worked in collaboration with Prof. Sidney Russ, and later was appointed director of the Research Department of the Radium Institute. With the inception of the Mount Vernon Hospital as a cancer hospital in 1931, he became its senior pathologist and director of pathological research, which position he held until his death on October 4.

Mottram's earlier work was devoted principally to the technique of radiotherapy. He did valuable work on the protection of X-ray workers, and served on the Radium and X-ray Protection Committee. Later he was concerned mainly with the problem of carcinogenesis. He was a man of very wide interests—a keen field naturalist, an expert fly fisherman of international repute, and an able water-colour artist, as well as an outstanding figure in cancer research.

His experience as a field naturalist and artist found practical application in the First World War, when he was appointed experimental officer in the Camouflage School of G.H.Q. He was the author of the article on natural camouflage in the "Encyclopædia Britannica" (12th edition, 1922). Another product of his interest in natural history was a book on "Controlled Natural Selection".

Mottram's wide biological outlook greatly influenced his approach to the study of cancer. For his investigations he employed a variety of organisms. Whichever seemed most suitable for the solution of the problem in hand, that was the one he employed, and

modified his technique accordingly. He excelled at work which required the minimum amount of apparatus and the maximum amount of skill and patient observation. He endeavoured to simplify the study of the action of carcinogens on cells by employing Protozoa. The result of this project was published in "The Problem of Tumours" (1942), in which he developed the thesis that the fundamental change in the induction of malignancy occurs in the cytoplasm of cells, and results in unequal cell division. Later he suggested that "the genesis of tumours represents action on cell division, whereby the exactly equal division of essential cell constituents is so disturbed that abnormal cells are formed lacking essential constituents or having some of them in abnormal abundance". According to this hypothesis, most tumours should be induced by carcinogenic agents when cell division is most active, and in subsequent papers he adduced evidence that this was the case.

It was characteristic of the man that when stricken down by malignant disease, of the outcome of which there was no doubt, his interests never faltered. While in hospital he continued the writing of papers he had in preparation, and he completed his last book on fishing, which he illustrated himself, within a few weeks of the end. His optimistic outlook and unquenchable enthusiasm for research were an inspiration to those who were privileged to be his friends.

R. J. LUDFORD.

Dr. F. R. Cowper Reed

FREDERICK RICHARD COWPER REED was born in London on June 27, 1869, and died in Cambridge on February 8, 1946. From Harrow he went to Trinity College, Cambridge, in 1888, and was later elected a scholar. He was placed in the first class of the Natural Sciences Tripos Part 1 (1891) and Part 2 (1892), and was awarded the Harkness scholarship for geology and palæontology. In 1901 he gained the Sedgwick Prize for his work on "The Geological History of the Rivers of East Yorkshire" and in 1914 took the degree of Sc.D. Reed was appointed assistant to the Woodwardian professor of geology in 1892, and retained that post for twenty-five years, his chief duties being curatorial in the Woodwardian (later the Sedgwick) Museum. After his retirement he was able to devote himself entirely to research.

In the early years of his career, Reed did some field work and wrote on the geology of the country around Fishguard (1895) and around Waterford (1897–99); but his main work was in palæontology. He dealt with many different groups of invertebrates but was especially interested in Brachiopods and Trilobites. On British palæontology, in addition to numerous short papers dealing with faunas or with individual families or genera, he wrote two monographs for the Palæontographical Society on "The Lower Palæozoic Trilobites of Girvan" (1903–35) and on "The British Ordovician and Silurian Bellerophontacea" (1920–21). Another monograph was on the Ordovician and Silurian Brachiopoda of Girvan (*Trans. Roy. Soc. Edin.*, 1917).

Reed did a great deal of work for the Geological Survey of India and contributed several monographs to the *Palæontologia Indica* during the years 1906–44 dealing with the Palæozoic faunas of the northern and southern Shan States, of Spiti, the Central Himalayas, Yun-Nan, Kashmir, the Salt Range, Tibet, etc. He also described faunas from the Bokkeveld Beds of South Africa, the Trias and Permo-Carboniferous of Brazil and the Ordovician of New Zealand. His paper on "Pre-Carboniferous Life Provinces" showed a philosophical outlook.

Reed made numerous journeys overseas, visiting Canada, Jamaica, South Africa, Kenya, Uganda, Cyprus, Palestine, India, Ceylon and Burma. The knowledge gained on these expeditions stood him in good stead when writing his "Geology of the British Empire" (1921).

He was a man of kindly nature, but so much immersed in his work that he gave the impression of leading a somewhat solitary existence.

H. WOODS.

Mr. A. H. D. Markwick

SOIL engineering in Great Britain has lost one of its most distinguished workers in the death on March 5, after a short illness, of Mr. A. H. D. Markwick at the early age of forty-one.

After graduating at the University of Manchester in 1924 with first-class honours in engineering, Mr. Markwick gained his early professional experience with two firms of consulting engineers, Messrs. C. S. Allott and Son and Messrs. Kennedy and Donkin. He entered the service of the Department of Scientific and Industrial Research at the Road Research Laboratory in 1933, and took charge of the Soils Section in 1937.

Mr. Markwick was a resourceful mathematician, a good linguist, and a sound practical engineer: his most outstanding quality was, however, his power of leadership and his ability to inspire his juniors with his own energy and enthusiasm. He came to soils engineering when the importance of the soil as a factor in road design and construction was little appreciated by British road engineers. He and his colleagues speedily remedied this state of affairs by carrying out extensive researches on soil compaction, soil stabilization and the problems involved in earth-moving and compacting machinery. This work formed the subject-matter of some twenty papers read before the Institution of Civil Engineers and other engineering bodies. The information gained proved of inestimable value during the war years, when Mr. Markwick's section was called upon to deal with many problems of aerodrome construction, the mud-crossing performance of tanks, beach-landing problems, and other special war problems concerned fundamentally with the supporting power of soil. The services of his section were also utilized by Supreme Headquarters in planning strategy and in co-ordinating the movements of armies with soil and ground conditions in the various theatres of war.

In all this work, Mr. Markwick took the leading part, and the successes achieved were largely due to his brilliance and energy. British engineering has lost a leader and his colleagues have lost a considerate and reliable friend.

T. LONSDALE.

WE regret to announce the following deaths:

Rai Bahadur Sir Upendranath Brahmachari, professor of tropical medicine, Carmichael Medical College, Calcutta, who discovered urea-stibamine and its value in treating kala-azar, on February 6, aged seventy.

Prof. Gilbert Newton Lewis, For.Mem.R.S., professor of chemistry in the University of California, aged seventy.

NEWS and VIEWS

Engineering at the University of Aberdeen: Prof. J. Allen

DR. J. ALLEN, senior lecturer in engineering in the University of Manchester, whose appointment to the Jackson chair of engineering in the University of Aberdeen has recently been announced, is a graduate of the University of Manchester, where he obtained the B.Sc. degree in 1926, and the D.Sc. in 1939. For the past eighteen years he has been actively engaged on research in the field of fluid flow, with more special reference to the use of tidal and river models. He acted as observer and recorder on the model of the Severn Estuary constructed and operated in the Engineering Department of the University of Manchester during 1926–33, for the Severn Barrage Committee, and has since been concerned in turn with tidal models of the Mersey, the Dee, the Humber, the Parrett, the Tay, and with a riverine model of the Upper Mersey. During the War he has been working on models of Scapa Flow, and of hydraulic structures for the Admiralty. The results of many of these investigations have been, or are shortly to be, published in the *Proceedings of the Institution of Civil Engineers*. Recently, Dr. Allen has been acting as a member of a small committee set up by the Department of Scientific and Industrial Research to report on the advisability of establishing a governmental institution of hydraulic research, on the lines of the famous Vicksburg Institution in the United States. He is the author of a work, now in the press, on "Scale Models in Hydraulic Engineering".

University of Reading: Retirement of Prof. J. A. Crowther

PROF. J. A. CROWTHER, who is shortly to retire from the chair of physics in the University of Reading—a post which he has held since 1924—has had a long and distinguished career in the sphere of physics. Educated at the Royal Grammar School, Sheffield, and St. John's College, Cambridge, his academic career led him to the Cavendish Laboratory; and his fellowship at St. John's and demonstratorship in physics attached him firmly to Cambridge during the period 1908–24. His early work prior to the First World War was in a most difficult field, but his investigations into the scattering of X-rays led to valuable results which have been incorporated into the great body of knowledge on this subject. It was his experience during 1914–18 at Cambridge, when the Cavendish Laboratory devoted some of its energies to the radiological treatment of war victims at a time when hospital X-ray facilities were practically non-existent, that his interests were deflected somewhat into the field of medical radiology. He became lecturer in physics applied to medical radiology at Cambridge during the three years preceding his appointment to the chair at Reading, and he has had very considerable successes in this field. His services outside the ambit of the young and growing University of Reading, which he has served so well, have placed him in several important and influential positions. He has been honorary secretary of the Institute of Physics since 1932; he was president of the British Institute of Radiology in 1936, and has been vice-chairman of the Parliamentary and Scientific Committee.

Prof. Crowther has a happy—a very happy—pen in the presentation of scientific principles, and his books in this particular line are well known to many generations of earnest students. The switch of his interests towards radiology and radiography is clearly indicated in the sequence of his published books, and in particular his editorship of the "Handbook of Industrial Radiology". It is to be hoped that his retirement will not mean his complete severance from the spheres of activity which he has served so well by pen, word and deed for the last forty years.

Retirement of Prof. H. Bassett

THE retirement of Prof. Henry Bassett from the chair of chemistry at the University of Reading will shortly remove from that University one of its most interesting figures. Student and collaborator of Ramsay, Baeyer and Donnan, he went in 1912, after work in London, Munich, Nancy and Liverpool, to take up his chair at a time when the young College was first aspiring to full university status. Under his guidance his department played its full part in the attainment of that dignity in 1926, and as dean during 1924–30 he must be credited in a special degree with the smooth and successful assumption by the Faculty of Science of the responsibilities of independence. In those formative years, Reading, with its growing fame in agriculture, was fortunate in having such a man as Bassett for its professor of chemistry. An analyst and inorganic chemist of repute, his wide knowledge of science covers not only the usual domain of chemistry but also extends far into the realms of geology and hydrography, botany and zoology. Besides his well-known phase-rule studies, his researches, which he still continues with unabated vigour, have led to papers on the potassium salts of phenolphthalein, the colour changes of cobalt chloride solutions, the conditions of formation of dithionates, the role of calcium phosphate in bone structure, and many others. A special feature of his work which reflects his knowledge of geology is his use of optical, morphological and X-ray crystallography in identifying research products. Vigorous still in body and spirit, he must be one of the youngest men to retire under a professorial age-limit, and his many students, colleagues and friends all over the world hope he may yet have many years to devote to the chemistry he loves and the cycling and camping he enjoys.

Physics at Oxford

THE new Clarendon Laboratory at Oxford, which was completed early in 1940, has been used during the War entirely for research on radar and on the separation of isotopes. With the advent of peace it is to be hoped that the Oxford Physics School will be able to resume research in the low-temperature field, for which it was so well known, and in the domain of nuclear physics. With the increased Government grants which are becoming available, the University of Oxford will no doubt do its part in extending research as well as teaching. But with all the conflicting claims there is bound to be a great deal of delay and frustration in obtaining new money for special researches, even in such an important subject as physics. The offer of the Nuffield Foundation to provide an annual grant of £8,000 for eight years to the Clarendon Laboratory in order to enable research to be expanded in Oxford beyond anything the University might reasonably be expected to finance is therefore particularly satisfactory. With this benefaction the Department should be able to tide over the transitional period and to develop

rapidly the Physics School at Oxford on a proper scale. Approximately £5,500 is to be devoted to Nuffield Foundation fellowships, and the donors properly—and somewhat exceptionally—have realized that extra research fellows entail extra expenditure in the way of technical assistants and so forth, and have accordingly made provision for another £2,500 a year to be used for such purposes. By this judicious and timely gift, Lord Nuffield has greatly added to the debt which science in Britain already owes him.

Science and Culture

THE January issue of *Science and Culture* (India) is the Science Congress number. The whole issue does credit to its editors and contributors. There are three articles dealing with the Geological Survey of India in both retrospect and prospect. Dr. Joseph Needham, whose articles on science in China have been published periodically in *Nature*, contributes a very informative review of the National Academy of Peiping and its activities during the War; this is accompanied by a useful map. A reproduction of Prof. Niel Bohr's article on "A Challenge to Civilization" is timely. "For meeting the challenge to civilization in the proper spirit it should be a most fortunate omen that we have to do with implications of pure scientific studies pursued with no other aim than to widen the borders of our knowledge and to deepen our understanding of that nature of which we ourselves are a part. Let us hope that the science which, through the ages, has stood as a symbol of the progress to be obtained by common human striving, by its latest emphasis on the necessity of concord, may contribute decisively to a harmonious relationship between all nations."

Prof. S. K. Mitra and Dr. J. N. Bhar contribute a useful article on developments in radar. Apart from more special articles, this issue of *Science and Culture* contains a number of research announcements in the form of letters to the editors. There are also informative articles on Bangalore and on the general president and the sectional presidents of the Science Congress. It is becoming increasingly clear that every country, or at any rate every cultural group, needs its own general scientific journal. In many cases, such journals already exist; and *Science and Culture* is one of the best of them. Published monthly, it covers all branches of science, naturally devoting special attention to science in India. We congratulate the editors on this special number, and commend the journal to all men of science and others. It is deserving of all possible support.

Jute Research in India: Prof. B. C. Kundu

ACCORDING to *Science and Culture* (India), of January, Prof. B. C. Kundu, professor of botany in Presidency College, Calcutta, has been appointed director of jute agricultural research, in charge of the Agricultural Research Laboratories, of the Indian Central Jute Committee, at Dacca. Prof. Kundu obtained a first-class master's degree in botany in the University of Calcutta in 1927, being first in order of merit. After a short period of service as a lecturer in botany, Ravenshaw College, Cuttack, he took up research work in the University under Prof. S. P. Agharkar, on being awarded the Sir Rash Behary Ghosh research scholarship. He served as a lecturer in botany, Rajshahi College, Bengal, during 1930–37. In the latter year he proceeded to Britain on study leave, and worked under the late Prof. J. B. Priestley, of the University of Leeds, on the fibre plants of India with special reference to their development, growth and structure. He has been serving as a professor of botany in Presidency College, Calcutta, and as honorary lecturer in the University of Calcutta, since 1939. During these years he has been working on jute, sunn hemp, *Hibiscus* and other fibre-yielding plants and has published a number of papers on these in various journals. As honorary secretary of the Botanical Society of Bengal, he has shown noteworthy powers of organisation.

Organisation of Science in Great Britain

AT a meeting of the Society of Visiting Scientists on January 23, there was an interesting discussion on the organisation of science in Great Britain, following on papers by Mr. O. F. Brown, of the Department of Scientific and Industrial Research, Mr. J. C. F. Fryer, secretary of the Agricultural Research Council, and Sir Edward Mellanby, secretary of the Medical Research Council. Of the three institutions, the Department of Scientific and Industrial Research appears to be the most centralized, while the Medical Research Council is as nearly independent as a Government department can be; Prof. M. L. Oliphant, in proposing the vote of thanks, was emphatic that this type of organisation is the right one even for applied research. Sir Edward Mellanby stressed that the Medical Research Council never works to a programme but concentrates on the man, letting him go ahead with his particular research and not dictating its conduct. The Council endeavours to encourage research in the universities and hospitals, and particularly the flow of men back to the universities. Dr. Solandt, however, questioned whether more than one in every four or five men of science is good enough to be left free for independent research along self-chosen lines, and suggested the need for one body to survey the overall scientific needs and man-power requirements of the community, so that no field may be left vacant. Mr. Fryer referred, in his address, to this question of shortage of man-power and equipment, and the problem of maintaining an adequate balance between fundamental and applied research. The integration of one field of scientific work with another constitutes a major problem, and he believes that it is such 'bridging' subjects as soil microbiology, animal husbandry, feeding and pathology that are likely to lead to progress in the future.

Mr. Brown, in reply to a question, explained that the new Production Engineering Section of the Department of Scientific and Industrial Research is concerned with the working of metals and fundamental research on machine tools and not with methods of organisation. Dr. Julian Huxley, discussing the question of co-ordination, commented on the anomalous position of the British Museum (Natural History) as the only scientific Government institution in Britain with no scientific advisory committee. He agrees with the view that horizontal or applied research should be under a central body while fundamental research should come under the various departments; there is, however, no body concerned primarily with the encouragement of pure biological research. Mr. Brown also expressed the opinion that, in future, such bodies as the Department of Scientific and Industrial Research would be more concerned with fundamental research, while problems of the application and development of research results would be handled by the ministries or by industry.

Proposed National Research Development Corporation

An amendment tabled on February 26 to the Investment (Control and Guarantees) Bill, supported by several members of the Parliamentary and Scientific Committee, proposes the establishment of a National Research Development Corporation with a guarantee of up to £10,000,000 a year from the Treasury for its use. Its purpose would be the development of any new invention or scientific discovery likely to lead to the creation of a new industry or to a substantial and beneficial change in any process used in any existing industry, agriculture or medical practice, and, second, the establishment of experimental plants and conduct of experiments with a view to the introduction of new industries and testing the suitability of new processes for existing industries, agriculture or medical practice. It is also provided that the Treasury may arrange that, in return for making good any guarantee, there shall be participation in "profits, patent rights or royalty payments which may in due course accrue to the National Research Development Corporation".

International Conference on the Problem of Overfishing

An international conference is sitting in London for the purpose of examining the question of overfishing, and, if possible, of drawing up some form of regulatory agreement among the nations concerned. Such an agreement is essential if a recurrence is to be obviated of what took place after the First World War with such disastrous results, when the stocks of fish accumulated during the war years in the North Sea, for example, were rapidly depleted by overfishing, and fishing operations soon became uneconomical. The following countries are represented at the conference: Norway, Sweden, Poland, Denmark, Holland, Belgium, France, Portugal, Spain, Eire, Iceland, Great Britain, and in addition the International Council for the Exploration of the Sea, which has for many years given attention to this problem.

Rheology in the United States

Interest in rheology has increased in recent years, and with the relaxation of censorship restrictions on scientific publications several important papers in industrial rheology (ten or fourteen papers) were contained in the programme arranged for the annual meeting of the Society of Rheology held in New York City during October 26–27. Prof. E. C. Bingham found the plotting of fluidities more helpful than the plotting of viscosities when dealing with anomalies of flow, and instanced the linearity of fluidities for many protein solutions. A theoretical discussion on the rate process theory of flow, applied to viscous liquids, by A. Bondi, was illustrated by numerous examples, and an interpretation given of the energy of hole formation in terms of the Lennard-Jones theory of the liquid state. A paper on the theory of strain hardening under combined stresses was given by W. Prager, who was concerned with isotropic incompressible plastic materials. T. Alfrey dealt with stress-strain curves for visco-elastic materials obeying the Boltzmann superposition principle. The industrial papers included the viscosity of oils at high pressure, the effect of plasticizers on the visco-elastic properties of vinyl resins (W. Aiken, T. Alfrey, A. Jansson and H. Mark), the viscosity of cellulose acetate solutions and of dilute solutions of polystyrene. Rotation cylinder viscometers were described, including a cylinder type for measurements during thixotropic recovery for a compounded latex, and a parallel plate type for high polymers. The need for an improved understanding of fundamentals leading to better methods was emphasized.

Sound Recording on Magnetic Film

Mr. D. W. Aldous, technical secretary of the British Sound Recording Association (BCM/BSRA, London, W.C.1), has written directing attention to the fact that the use of an iron powder film for the magnetic recording of sound (see *Nature*, January 19, p. 71) was known some years before the War. This technique was used in the magnetophone developed by the Allgemeine Elektricitäts-Gesellschaft, and it was described by Prof. Erwin Meyer, of Berlin, in a course of lectures given in 1937 under the auspices of the University of London; these lectures were afterwards published in a book entitled "Electro-Acoustics" (G. Bell and Sons, Ltd., 1939). Apart from the improved technical quality, the chief advantage of the method is the comparative cheapness of the tape recording-medium. Another German firm has developed a pressing process for embossed ribbon recordings, which has useful possibilities for the multiplication of records. It is also understood that British and American workers are active in the field of magnetic sound recording, and that new designs of wire and tape recorders, having applications for commercial and domestic use, may be expected in the future.

Aerial Photographs for Scientific Purposes

From time to time aerial photographs are required for scientific purposes. Facilities for such photographs, required for non-commercial scientific purposes, may be provided by the Royal Air Force and Royal Navy; but it will be readily understood that such facilities are limited, and priority must therefore be allocated to the various requirements. The Advisory Committee on Airborne Research Facilities, a joint committee of the Royal Society and the Services, is to advise the Services on this matter. Requirements for photographs to be taken during 1947 should be forwarded to the Committee, at the Royal Society, Burlington House, London, W.1, before October 31, 1946; it will assist if the envelope is marked 'Aerial Photographs'.

Annales d'Astrophysique

The French National Centre of Scientific Research announces that, beginning with this year, the *Annales d'Astrophysique* will be reorganised as an international medium for the publication of articles on astrophysics. Prof. F. Joliot-Curie, director of the Centre, has nominated a French committee to organise the French Service d'Astrophysique (Upper Provence Observatory, Institute for Astrophysics in Paris, *Annales d'Astrophysique*, etc.): *Chairman*, Prof. A. Danjon, director of the Paris Observatory; *Vice-chairman*, M. Chalonge, astronomer at the Paris Observatory and at the Institute of Astrophysics; *Secretary*, H. Mineur, astronomer of the Paris Observatory and director of the Institute of Astrophysics; *Members*, Messrs. Coulomb, Dufay, Fehrenbach, Lyot, Couder, Lallemand and Barbier. Dr. D. Barbier has been appointed editor-in-chief for the *Annales*. An international board of foreign correspondents has also been formed including Messrs.

Abetti, Beals, Gaviola, Lindblad, Mayall, Menzel, Merrill, Cort, Plaskett, Redman, Russell, B. Strömgren, Struve and Swings. Under the new plan the *Annales* will accept articles from all countries and will be prepared to print them in French, English or German. During the War the *Annales* published two issues a year. Those dated 1945 are expected to appear shortly. The first issue of 1946, which will start the international series, is expected to appear in the middle of the year. The address of the editor is Dr. D. Barbier, Institut d'Astrophysique, 98 bis, Boul. Arago, Paris (14ème), France.

The Night Sky in April

NEW moon occurs on April 2d. 04h. 37m. U.T. and full moon on April 16d. 10h. 47m. The following conjunctions with the moon take place: April 8d. 19h., Saturn 2° S.; April 9d. 07h., Mars 0·2° S.; April 16d. 01h., Jupiter 3° S.; April 29d. 15h., Mercury 2° N. Occultations of stars brighter than magnitude 6 are as follows: April 6d. 19h. 46·8m., n Taur. (*D*); April 20d. 01h. 23·9m., ω Ophi. (*R*); April 21d. 02h. 39·8m., b Ophi. (*D*); April 21d. 03h. 54·0m., b Ophi. (*R*). The times are for Greenwich and (*D*) and (*R*) refer to disappearance and reappearance respectively. Mercury rises shortly before sunrise and is not well placed for observation. The planet is stationary on April 11 and attains its greatest western elongation on April 23. Venus is conspicuous in the western sky for some time after sunset, setting at 19h. 47m. and 21h. 19m. at the beginning and end of the month respectively. The apparent area of the illuminated disk on these dates is 0·970 and 0·929, that of the entire disk being the unit. Mars is in the constellation of Gemini early in the month and moves into Cancer later on. The planet is visible throughout the greater portion of the night, setting at 3h. 16m., 2h. 35m., and 1h. 51m. at the beginning, middle and end of the month respectively. The stellar magnitude of Mars varies from 0·7 to 1·1 between April 1 and 30. Jupiter is well placed for observation, rising at 19h. 37m., 18h. 26m., and 17h. 17m. at the beginning, middle and end of the month respectively. The planet is in opposition to the sun on April 13, and its magnitude is −2·0 throughout April. Saturn, in Gemini, can be seen through the night and early morning hours, setting at 2h. 44m., 1h. 51m., and 0h. 56m. at the beginning, middle and end of the month respectively. The Lyrid meteors are due from about April 18–22, but moonlight will partly interfere with observations of this shower.

Announcements

MR. H. G. STRAUSS (Conservative) has been elected member of Parliament for the Combined English Universities in the by-election caused by the death of Miss Eleanor Rathbone.

THE Rockefeller Foundation has made a grant of 19,000 dollars to the University of Oxford for research on anti-biotics, under the direction of Sir Howard Florey, professor of pathology.

BRIGADIER M. HOTINE, director of military surveys, War Office, has been appointed by the Colonial Office to be director of Colonial geodetic and topographical surveys. He will be the head of a new central organisation for topographical and geodetic surveys in the Colonial Empire. Lieutenant-Colonel G. J. Humphries, lately of the Nigerian Survey Service, has been appointed deputy director of Colonial surveys.

DR. ROBERT B. JACOBS, previously engineer in charge of high-vacuum development and research for the Kellex Corporation, which designed the gaseous diffusion plant for atomic energy developments at Oak Ridge, Tennessee, has joined the staff of Distillation Products, Inc., Rochester, N.Y., where he will take charge of work on physical phenomena at low pressures.

A SYMPOSIUM of papers on "Degaussing" has been arranged for meetings of the Institution of Electrical Engineers to be held on April 4 and 5, at 5.30 p.m. Seven papers covering various aspects of the subject are to be given.

AN Arnold Gerstenberg studentship for philosophical study, of the annual value of about £150 and tenable for two years, will be offered at Cambridge next year. It will be open to men and women who have obtained honours in either part of the Natural Sciences Tripos and whose first term of residence was not earlier than the Easter term of 1941 (except those who have been on war service). The studentship will be awarded for an essay to be submitted before May 1, 1947. Further particulars of the studentship, of the subjects for essays, and of the condition applicable to candidates who have been on war service, may be obtained from Mr. R. B. Braithwaite, King's College, Cambridge.

A COURSE of six lectures on microscopy, suitable for those having to use the microscope in technical practice, and including advanced methods in microscopy, will be given by Mr. B. K. Johnson in the Technical Optics Section of the Imperial College of Science and Technology, London, S.W.7, on Tuesdays and Thursdays at 4 p.m., beginning April 25. An optional course of practical work will be arranged during the eight weeks commencing May 20. Applications to attend should be sent to the Registrar of the College.

THE American Telephone and Telegraph Company has announced the award of five Frank B. Jewett fellowships. The purpose of the fellowships is to stimulate and assist research in the fundamental physical sciences, and particularly to provide the holders with opportunities for individual growth and development as creative workers. The awards carry an annual stipend of 3,000 dollars to the holder and 1,500 dollars to the institution at which the recipient elects to do research. The new fellows, with their subjects of research, are: Dr. Martin G. Ettlinger (chemistry of cyclopropane, cyclopropene and dicyclobutane derivatives); Dr. Edward W. Fager (photosynthesis in green plants); Dr. Bernard Goodman (very high energy particles and processes); Dr. Shuichi Kusaka (theoretical physicist, in the Army of the United States, stationed at Wright Field, Ohio); Dr. Robert L. Scott (thermodynamics of solutions).

IN the article on "Kilimanjaro" by J. J. Richard published in *Nature* of September 22, 1945 (p. 352), the scale of upper air temperatures (Curve *C*) was inadvertently omitted from Fig. 3; the temperatures at the dates of crater fumarole readings were 22, 23, 23, 19, 17, 19, 20, 22, 25, 25° F., showing a variation of only 8° F. In Fig. 2, the date against fumaroles 1–5 should be Oct. 10, 1942; and "Northern Ice Carrier" should read "Northern Ice Barrier".

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Hypothesis on Compressibility at Pressures of the Order of a Million Atmospheres

I HAVE earlier pointed out[1] that the incompressibility k appears to change surprisingly little across the boundary (at depth of 2,900 km.) between the earth's mantle and the central core. Formal calculations[1,2] based on my results for the earth's density distribution[3,4,5] gave $k = 6{\cdot}5 \times 10^{12}$, $6{\cdot}2 \times 10^{12}$ dynes/cm.[2] for the materials just above and just below the boundary, respectively. The difference between these two values is, moreover, within the uncertainty of the determination. Furthermore, I find that when values of k are plotted against values of the pressure p in the earth's interior, there is no significant difference indicated in the values of dk/dp above and below the core boundary. On the other hand, it is well established that this boundary sharply separates materials that are widely different in rigidity and in density.

The suggestion therefore arises that, at the very high pressures obtaining in the earth's deep interior, that is, at pressures of the order of 10^{12} dynes/cm.[2], the compressibility of a substance may be largely independent of its particular chemical constitution. Dr. W. Boas of this University informs me that this suggestion is plausible from the point of view of theories of atomic structure and of laboratory investigations at high pressures; and this view is compatible with statements of Bridgman[6]. I have therefore ventured to put the suggestion forward as a tentative hypothesis that would entail a number of interesting consequences, some of which may possibly admit of being tested in the future. The following are points of interest connected with the hypothesis.

(i) If the compressibility is a fairly smooth function of the pressure throughout the earth's central core, it follows with a high degree of probability that the inner part of the central core (below a depth of order 5,000 km. beneath the earth's outer surface) is solid, that is, possesses significant rigidity (μ); this rigidity would be of the same order as that pertaining in the earth's mantle.

This inference follows from a consideration of the formula $\{(k + 4{\cdot}3\mu)/\rho\}^{1/2}$ (where ρ denotes density) for the velocity of P seismic waves, in the light of (*a*) the strong probability that the outer part of the central core is in an essentially fluid state; (*b*) the observed marked increase[7] in the P velocity from the outer to the inner part of the central core; (*c*) the improbability of the density decreasing with increase of depth.

It may be noted that even if the main hypothesis set down above should turn out to be not substantiated, there still remains a likelihood of the inner core being solid. This follows since one would *a priori* expect any change in compressibility between the two portions of the central core to be not more pronounced than the change between the outer central core and the mantle. The argument just stated would thus still be relevant.

(ii) As a consequence of (i), a possible explanation of the earth's permanent magnetism would be forthcoming. A discussion by Birch[8] on the alpha-gamma transformation of iron indicates that the Curie temperature of alloys containing γ-iron may conceivably increase with increase of pressure at a sufficient rate to allow of the existence of a ferromagnetic inner solid core in the earth.

(iii) The hypothesis would, if correct, lead to an increased precision in figures for the density variation in the earth, inasmuch as an additional equation of condition would in effect be provided.

(iv) It would follow that the mean density of the inner part of the central core exceeds 14 gm./cm.[3].

(v) The sudden changes[9] in values of the P and S velocity gradients setting in at a depth of about 410 km. below the earth's outer surface could be explained as the setting in of a pressure phenomenon independently of chemical composition. This could be an alternative, or perhaps supplementary, explanation to Bernal's hypothesis[10] that the changes at this order of depth in the earth are due to a rearrangement in the crystalline state of the material present.

(vi) The hypothesis would, in relation to the observed diminutions[11] in the P and S velocity gradients in the region extending to about 200 km. immediately above the earth's central core, suggest an increased density gradient in this region over that in the remainder of the lower part of the earth's mantle.

(vii) The hypothesis would lead to a number of quantitative relations which might be of interest to physicists in general, and which would perhaps be capable of being tested, or checked from other theoretical work, in the future. For example, $0{\cdot}39 \times 10^{12}$ dynes/cm.[2] would be indicated as the pressure above which the (p, k) relation would, at the temperature prevailing in the earth, become independent of the chemical composition. Further, the form of the (p, k) relation (at the temperature prevailing in the earth) would be available over a range of pressure from $0{\cdot}39 \times 10^{12}$ to about $3{\cdot}2 \times 10^{12}$ dynes/cm.[2], the latter being the pressure at the boundary of the inner core.

(viii) If the earth's inner core were significantly solid, it would be capable of transmitting significant S seismic waves. This suggests the project of setting up an earth model incorporating the above compressibility hypothesis, and evolving corresponding theoretical travel-time tables for phases such as *PKJKP*, say, where P as usual denotes passage of a wave in the P type through the earth's mantle, K passage in the P type through the outer part of the central core, and J passage in the S type in the inner core. It would, of course, need to be calculated whether sufficient energy would go into a pulse of this type to enable it to be observable at the earth's outer surface; also, allowance would need to be made for some uncertainty in the value of the rigidity of the inner core. But there is the possibility of a seismological test being ultimately made in this way.

The above features appear to be sufficiently interesting to warrant the carrying out of some detailed work on this compressibility hypothesis; and I propose to publish later a more complete quantitative discussion.

K. E. BULLEN.

Department of Mathematics,
University, Melbourne.
Dec. 6.

[1] Bullen, *Trans. Roy. Soc. N.Z.*, **71**, 164 (1941).
[2] Bullen, *Trans. Roy. Soc. N.Z.*, **70**, 137 (1940).
[3] Bullen, *Mon. Not. Roy. Ast. Soc., Geophys. Suppl.*, **3**, 395 (1936).
[4] Bullen, *Bull. Seis. Soc. Amer.*, **30**, 235 (1940).
[5] Bullen, *Bull. Seis. Soc. Amer.*, **32**, 19 (1942).
[6] Bridgman, "The Physics of High Pressure" (G. Bell and Sons, London, 1931), 182.
[7] Jeffreys, *Mon. Not. Roy. Ast. Soc., Geophys. Suppl.*, **4**, 510 (1939).
[8] Birch, *Amer. J. Sci.*, **238**, 211 (1940).
[9] Jeffreys and Bullen, *Nature*, **131**, 97 (1933).
[10] Bernal, *Observatory*, **59**, 268 (1936).
[11] Jeffreys, *Mon. Not. Roy. Ast. Soc., Geophys. Suppl.*, **4**, 602 (1939).

Some Thoughts on Nomenclature

OUR planet the earth is studied in many ways, some of which correspond roughly to the main divisions of universal science, for example, mechanics, physics and chemistry. Such specialized branches of the universal sciences are appropriately indicated by the prefix 'geo', giving the words 'geomechanics', 'geophysics' and 'geochemistry'. These are modelled on the old word 'geometry', which itself has long since lost its special association with the earth, to become the name of the universal science of the measurement and properties of space. Hence the need for another word ('geodesy') relating to the measurement of the 'figure' of the earth, which must be the basis of geography, the mapping of the earth. The meaning of geography has gradually become elaborated to include much more than graphical representation, and besides physical geography, which shades off into geophysics, covers studies that merge into economics, sociology and general biology.

Another venerable word, 'geology', the significance of which has always been more limited than the word might imply, has nevertheless with time gained a deeper and wider content, so that now it covers many subdivisions which likewise shade off near their boundaries into geophysics, economics and biology (past and present).

I have long thought that a comprehensive word is needed to comprise all these branches of the study of the earth, and the recent growing use of the terms 'the earth sciences' and 'geo-science' in America indicates that others have felt the same need. I wish therefore to propose for this purpose the word 'geonomy', analogous to the ancient word 'astronomy', which has many parallel branches—such as astrophysics, astrometry and astrography, not to speak of the now despised astrology.

The analogy can usefully be carried further. The word 'geonomer', like geonomy, flows smoothly from the tongue, and would comprise not only the geologist and geographer but also such awkwardly named vocations as geophysicist (a too sibilant word), geomagnetician and meteorologist.

The corresponding adjective might be either 'geonomic' or 'geonomical'; 'geonomic' seems preferable for its brevity, and has respectable precedents to justify it, such as 'economic'.

The termination 'nomy' also offers a convenient means of creating a new word to replace 'meteorology', which, especially in its English adjectival form, is excessively polysyllabic; and the association of meteorology with the beautiful word 'meteor' is now irrelevant and misleading. I propose that the word be abandoned in all its many official and unofficial uses, in favour of 'aeronomy' (with the associated words 'aeronomer' and 'aeronomic'): 'aerology' is of course an alternative, but already has a specialized meaning for a part of meteorology.

Possibly the same model might be followed to provide a name for the study of the ionosphere. 'Ionomy', 'ionomer', 'ionomic' might thus replace 'radio-physics' and the associated words, which are certainly less easy to pronounce, and in view of the possible confusion with the physics of radioactivity, somewhat ambiguous: it is to be admitted, however, that ionomy might seem applicable to the study of ions in the laboratory as well as in the ionosphere.

S. CHAPMAN.

Imperial College of Science and Technology,
London, S.W.7.
Dec. 19.

Control of Electrical Twinning in Quartz

IN the Dauphine twins of quartz, the polarity of the electric axes is reversed on either side of a twin boundary. Structurally the change is slight. It has been known for some time that electrical twinning could be induced either by heating[1] or by pressure[2]: but up to the present its elimination has not, so far as we are aware, been reported.

We have investigated the influence of stress upon quartz plates, bars and cylinders when heated and have found that by suitable combinations of stress and temperature upon particular cuts, the twinned parts of the crystal may be untwinned, so that the material hitherto rejected in the manufacture of quartz oscillators may be utilized.

The most useful method consists in applying a steady torque to a plate of suitable orientation, heated to a temperature which may be considerably below the α–β inversion point. This results, in a single treatment, in eliminating all the twin boundaries except for a small band running down the narrow edges, as shown in Fig. 1. Reversing the sense of the torque did not bring about a change in the polarity of the crystal developed, which depended only upon the orientation and shape of the plate relative to the crystal axes.

An investigation was made of a series of plates, the length in each case being perpendicular to the optic axis. In order to get substantially

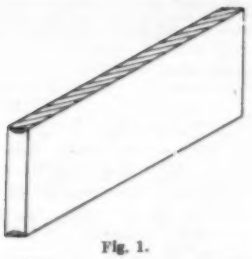

Fig. 1.

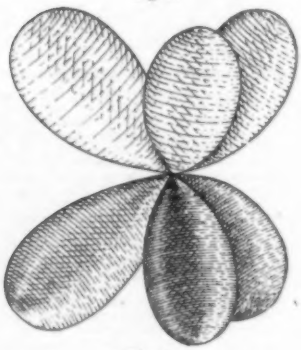

Fig. 2.

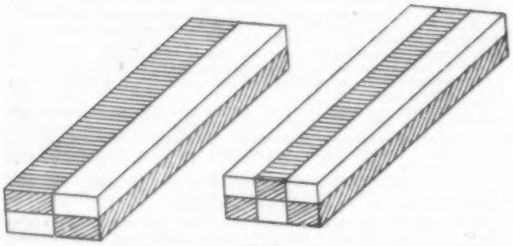

Fig. 3.

complete clearance, that is, freedom from twin boundaries, it was found that different loads were required for plates of different orientation; and with some cuts clearance could not be effected even with loads which were liable to cause fracture. The relation between the force required for what might be termed 'piezocrescence' and the direction relative to the crystallographic axes is shown in the solid figure in Fig. 2. Each radius vector of this surface is inversely proportional to the torque required to untwin the crystal and is drawn normal to the major surface of the plate. In this 'piezocrescent' figure the lighter lobes indicate where the orientation of the crystallographic axes x, y, u remains unchanged and the darker lobes where the polarity of these axes is reversed by the treatment. Only six lobes are shown, though twelve are really present, since from the method of definition it follows that a radius vector drawn in any direction must be of the same character and of equal amount to the radius vector drawn in the opposite direction.

Other experiments were performed applying bending stresses. These were found to give rise to characteristic twin patterns in certain cuts. Experiments carried out on bars subjected to a temperature gradient while cooling from a temperature above the transition point also produced patterns which were characteristic of the cut. Presumably these patterns arose as a result of stresses set up by differential cooling. Some of them are shown in Fig. 3, and it is interesting to compare them with the similar patterns obtained by Zinserling[3] using a completely different method.

This work, of which a fuller account will be published elsewhere, has been done in co-operation with the Research Laboratories of the General Electric Company, Ltd., Wembley, and we are grateful to the director for permission to publish.

W. A. Wooster.
Nora Wooster.

Brooklyn Crystallographic Laboratory,
Cherry Hinton Road,
Cambridge.
Dec. 19.

[1] Zinserling, E. V., and Laemmlein, G. G., *C.R. Acad. Sci. U.S.S.R.*, **33**, 419 (1941).
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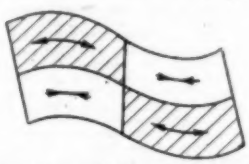
[3] Zinserling, E. V., Collected works, Institute of Crystallography, Moscow, **2** (1940).

Users of quartz crystals for telecommunication purposes will be anxious to know the practical importance of the results described by Dr. and Mrs. Wooster on the untwinning of quartz plates. The most effective method, in which a steady torque is applied to the plate during heat treatment, can be used for most cuts of the rotated Y-cut class. These include the important *BT* cut, but exclude the Y-cut itself and the Z-cut. In applying the treatment, depending on the fulfilment of certain conditions which will be discussed elsewhere, the proportion of successes can be so high that the large-scale processing of quartz plates to remove electrical twinning is a practicable proposition. This method can thus be applied directly to the majority of the practical cuts with the noteworthy exception of the X-cut. The X-cut can be treated by other means which, however, are at present less effective.



The regular twin patterns obtained by Dr. and Mrs. Wooster are of more practical interest than might at first appear. For example, the production of artificial twins of the kind shown in their Fig. 3 has enabled oscillator plates of a novel type to be cut. By metallizing the major surfaces of such a plate and applying an alternating electrical potential to the electrodes so formed, it is possible to excite a second order flexural mode of vibration in the plane of the plate. This is illustrated in the accompanying drawing, the arrows showing the sense of the strain in each of the four regions during one half-cycle. The type of deformation obtained is exaggerated for clarity. To obtain a similar result with a single crystalline plate, specially divided metallized electrodes would have to be used.

L. A. Thomas.
J. L. Rycroft.

Research Laboratories,
General Electric Company, Ltd.,
Wembley.

Edward A. Fielding.

Salford Electrical Instruments, Ltd.,
Burns Mill,
Heywood, Lancs.
Jan. 4.

Osmotic Pressure of Rod-shaped Particles in Solution

It has been pointed out by several workers, Dobry[1] and Wo. Ostwald *et al.*[2], that Van't Hoff's relationship between the osmotic pressure p and the concentration C of a dissolved substance

$$p = RTC$$

is a limiting law. Some substances such as the sugars obey this law up to relatively high concentrations[3], but high molecular substances, especially those the molecular shapes of which deviate greatly from the spherical, show considerable departures from the linear relationship between osmotic pressure and concentration.

The equation of Haller[4] derived thermodynamically gives a very good interpretation of the results of osmotic pressure measurements. The equation

$$p = \frac{RT}{V^0}\left(\frac{n_1}{n_0}\right)\left[1 + \left(\frac{\beta}{RT} - \frac{1}{2}\right)\left(\frac{n_1}{n_0}\right) + \left(\frac{2\gamma}{RT} + \frac{1}{3}\right)\left(\frac{n_1}{n_0}\right)^2 + \ldots\right] \quad \ldots (1)$$

in which V^0 is the molar volume of the solvent, n_1 and n_0 the number of molecules of solute and solvent respectively and β and γ are constants. From the above equation it is evident that a first approximation to the osmotic pressure is

$$p = \frac{RT}{V^0}\left(\frac{n_1}{n_0}\right) + K\left(\frac{n_1}{n_0}\right)^2$$

in which K is a constant, and if still better approximations are required terms like

$$L\left(\frac{n_1}{n_0}\right)^3 \text{ and } M\left(\frac{n_1}{n_0}\right)^4$$

may be added.

From the above it is clear that the interpretation of osmotic pressure measurements depends on the determination of the constants K, L and M which vary with different substances.

In this communication an expression for the dependence of the osmotic pressure on the concentration for rod-shaped particles is given in terms of the ratio of the diffusion constant at a certain concentration, to the diffusion constant at infinite dilution.

A rod-shaped particle in solution, in the absence of other particles of its own type, will show Brownian motion of translocation as well as rotation round either of its axes. The translocatory motion can be expressed in terms of the diffusion constant by the following equation[3,4]:

$$D_0 = \frac{X^2}{2t} = \frac{1}{3}\frac{al^2}{2t} \quad \ldots (2)$$

where D_1 is the diffusion constant at infinite dilution, X is the distance traversed in time t and a is the number of steps of arbitrary length l.

The Brownian movement of any given particle will be dependent upon the absence or presence of other particles.

The particle will not be free to rotate round its short axis as it did at infinite dilution, but will continually collide with neighbouring particles. The larger the number of particles per given volume of solution the more frequent will be the collisions. Each collision with a particle will cause an extra displacement of its centre of rotation in addition to that caused by the molecules of the solvent. For the sake of simplicity let the displacement per collision be l (see equation 2), then following the De Haas-Lorentz deduction of the right-hand side of equation 2 the diffusion constant through impacts with molecules of the same type can be expressed by the following equation:

$$D_1 = \frac{X_1^2}{2t} = \frac{1}{3}\frac{a_1 l^2}{2t}$$

where X_1 is the distance traversed through impacts with similar molecules and a_1 is the number of such impacts in time t. The diffusion constant of rod-shaped particles in a concentrated solution can therefore be represented by

$$D_c = D_0 + D_1 = \frac{1}{6}\frac{l^2}{t}(a_1 + a).$$

This can be written in the form

$$D_c = D_0 + nD_0 \quad . \quad . \quad . \quad . \quad (3)$$

n can be any number, or

$$D_c = \frac{RT}{Nf} + \frac{nRT}{Nf} \quad . \quad . \quad . \quad . \quad (4)$$

where R is the gas constant, T the absolute temperature, f is the frictional constant of the particle and N is the Avogadro's number[7,8].

From equation 4 it follows that

$$D_c \cdot \frac{dc}{dx} = C\left[\frac{1}{Nfc}(RT + nRT)\right]\frac{dc}{dx}.$$

According to the diffusion law the amount of solute that passes through a layer of thickness dx and cross-section 1 cm.^{2} in 1 sec. in a column is given by

$$D_c \frac{dc}{dx} = Vc.$$

c is the concentration in a layer of thickness dx and V is the velocity of the particles in the direction x

therefore

$$V = \frac{1}{f} \cdot \frac{1}{Nc}\left[RT\frac{dc}{dx} + RTn\frac{dc}{dx}\right]$$

or

$$V = \frac{1}{f} \cdot \frac{b}{Nc} = \frac{F}{f}, \text{ where } F = \frac{b}{Nc}$$

which is driving force per molecule, and

$$b = RT\frac{dc}{dx} + RTn\frac{dc}{dx}$$

which is total driving force. The total driving force in diffusion is the gradient in osmotic pressure

$$b = \frac{dp}{dx} = RT\frac{dc}{dx} + RTn\frac{dc}{dx}.$$

Therefore

$$p = KTc + RTnc.$$

On substitution in equation 3 it follows that

$$p = RTc\left[1 + \left(\frac{D_c}{D_0} - 1\right)\right] \quad . \quad . \quad . \quad (5)$$

or

$$p = RTc\frac{D_c}{D_0}.$$

Gralén[9], in his exhaustive studies on sedimentation and diffusion constants of cellulose derivatives, showed that there is a linear dependence of the diffusion constant on the concentration. This he wrote in the form

$$\frac{D_c}{D_0} - 1 = Sc;$$

S is a constant. On substitution in equation 5 it follows that:

$$p = RTc + RTSc^2 \quad . \quad . \quad . \quad . \quad (6)$$

Equation 6 is identical with Haller's equation and with Wo. Ostwald's empirical equation[1]

$$p = RTc + \alpha c^k \quad . \quad . \quad . \quad . \quad (7)$$

α and k are constants; k varies between 1·8 and 2·3 depending on the substance.

It has been observed by Polson[10] and Gralén[9] that the diffusion constants of cellulose derivatives increase with increasing concentration. The more asymmetric the molecule investigated the greater was the effect observed. This is in agreement with equation 3.

A. Polson.

Veterinary Research Laboratories,
Onderstepoort,
South Africa.
Oct. 11.

[1] Dobry, *Kolloid Z.*, **81**, 190 (1937).
[2] Wo. Ostwald *et al.*, *Kolloid Z.*, **24**, 7 (1919); **49**, 60, 74 (1929); **51**, 361 (1930); *Z. Phys. Chem.*, A, **159**, 375 (1932).
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Time Factor and Minima in Tension Curves

In an investigation of the influence of methylcellulose on the interfacial tension between cyclohexane and water[1], a modified drop-volume method[2] similar in principle to the drop-weight method described by Addison[3] was employed to study the time factor. The relationships found between interfacial tension and time were essentially of the same form as obtained by Addison[3] in the case of surface tension, but minima were observed in these tension – time curves, which are displaced towards zero time and become more pronounced as the concentration increases. Such minima have also been observed in surface tension – time curves[4].

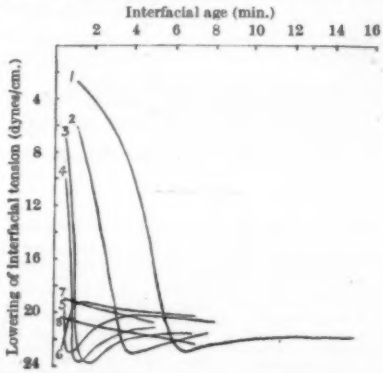

Fig. 1. Time factor in the influence of methylcellulose on the interfacial tension between cyclohexane and water.

1.	0·0014 % methylcellulose		5.	0·0047 % methylcellulose	
2.	0·0019	"	6.	0·0095	"
3.	0·0028	"	7.	0·0189	"
4.	0·0038	"	8.	0·0284	"

The minima are absent from the experimental curves corresponding to the higher concentrations, for example, curves 6, 7 and 8 of Fig. 1, but by comparison with the full curves obtained with the more dilute solutions the probable explanation for this is seen to be that the minima in these curves occur at interfacial ages too short to be explored by the experimental technique employed.

The significance of the rising portions of these curves is not clear, but the transient increase in interfacial tension might well be due to the expulsion of adsorbed molecules during the preliminary stage of molecular rearrangement at the dineric interface. This is supported by the increase with concentration of the rate at which this process occurs.

Whatever may be the ultimate explanation of these observed changes at the interface, they are important in providing a simple explanation for the existence of minima in tension – concentration curves. The latter have been extensively reported[5], and various explanations have been offered attempting to reconcile the existence of such minima with the Gibbs adsorption equation. Surface and interfacial tensions, however, have usually been measured without taking into consideration the time factor, and generally the tension has been determined throughout a concentration range upon a surface or interface of an arbitrarily fixed age. The result this has on the form of the tension – concentration curve is clearly shown in Fig. 2, where the relationships between tension and concentration for interfaces aged for 1 min. and 5 min. are compared with that obtained when the tension values for the oldest interfaces measured are used.

A trace of a shallow minimum still occurs in Curve 3 of Fig. 2, but this is probably due to the use of tension values for interfaces which, as shown in Fig. 1, had not completely reached the equilibrium state.

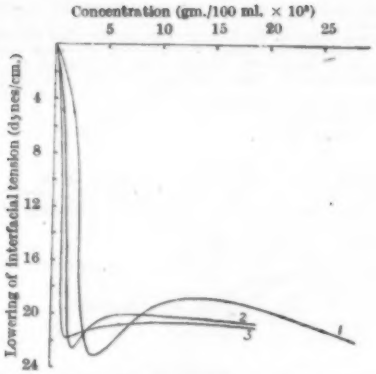

Fig. 2. Influence of varying interfacial age on the tension-concentration for the system cyclohexane–water–methylcellulose.
1, interfacial age, 1 min.
2, " " 2 min.
3, oldest interfaces measured.

Thus, one is led to conclude that minima in tension – concentration curves owe their existence solely to the use of tension data for surfaces or interfaces which are in differing states of rearrangement, and that if precautions are taken to make measurements on completely equilibrated surfaces or interfaces, this disturbing 'anomaly' will disappear.

Full details of this work will be published elsewhere.

John B. Matthews.

The Beacon,
Sandon Road,
Chester.
Nov. 23.

[1] Matthews, J. B., Ph.D. Thesis, Liverpool (1939).
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Molecular Weight Distribution of Proteins

The recent publication[1] of an examination of Svedberg's theory of molecular weight distribution, in which the theory is considered to be invalid, suggests that a treatment, similar in some of its details, might be of interest. This was prepared in 1944[2], and the conclusions agree with those of Johnston, Longuet-Higgins and Ogston[1], and with those of Bull[3]. It seemed clear that the explanation of the imperfection of his theory given by Svedberg[4], namely, that the mean molecular weights of the amino-acid residues in the different proteins were not the same, is inadequate, since, for example, the mean residue weights of zein and ovalbumin are in a ratio not far different from 1 : 1·1, while the molecular weights of the proteins themselves are in a ratio of approximately 1 : 1·3. Moreover, the arbitrary omission of gliadin, hordein and two haemocyanins from Svedberg's classification[4] needs a better reason than the maintenance of his hypothesis. Further, the existence of proteins of lower molecular weights than the basic unit of 17,600 (such as ribonuclease and cytochrome-*c* at 13,000) is a serious complication to the theory, and there are certain groups, such as Svedberg's '× 96' group, where the actual mean of the molecular weights cited is not even approximately that of the characteristic 'group value'.

The method of analysis adopted was this: (1) to divide the molecular weight given by Svedberg by his figure of 17,600, correcting his values for cytochrome-*c* and ovalbumin and adding the figure for ribonuclease; (2) to work out the geometrical mean of these ratios, and quote it as a logarithm against the logarithm of Svedberg's group number; (3) to obtain the actual standard deviation of the observed results from this mean, from the expression

$$\sigma = \sqrt{\frac{\Sigma\Delta^2}{(n-1)}}\ ; \quad . \quad . \quad . \quad . \quad (1)$$

(4) to obtain a value for the standard deviation of random distribution, assuming that if the values of successive Svedberg group numbers are A, B and C, the boundaries of group B can be fixed at $a = \sqrt{(AB)}$ and $b = \sqrt{(BC)}$. The random series is obtained by taking the geometrical progression, a, ar, ar^2, . . . $ar^n = b$, in the limiting case when $r \to 1$ and $n \to \infty$. The logarithm of the geometrical mean is then $\frac{1}{2}\log ab$. This random standard deviation will then conform to the formula:

$$\sigma_r = \frac{\log b/a}{2\sqrt{3}} \quad . \quad . \quad . \quad . \quad (2)$$

No lower limit could be assigned to the first group, for which no random deviation is therefore quoted.

Svedberg group number	Log_{10} group number	Log_{10} geom. mean	Svedberg standard deviation	Random mean value	Random standard deviation	σ/σ_r
1	0·000	$\bar{1}$·995	0·084	—	—	—
2	0·301	0·312	0·054	0·301	0·100	0·54
4	0·602	0·598	0·044	0·571	0·071	0·62
6	0·778	0·772	0·052	0·765	0·045	1·15
8	0·903	0·969	0·105	0·948	0·063	1·67
16	1·204	1·229	0·058	1·173	0·071	0·82
24	1·380	1·397	0·051	1·411	0·116	0·44
48	1·681	1·670	0·029	1·681	0·100	0·29
96	1·982	1·917	0·106	1·982	0·100	1·06
192	2·281	2·245	0·051	2·281	0·100	0·51

The results of this analysis are shown in the accompanying table. It is seen that in three of the groups (6, 8 and 96) the 'Svedberg deviation' is actually greater than the random figure, while in all the others it is so great in comparison with the latter that the disturbing factors which account for the divergence must be excessively large. Certainly the Svedberg hypothesis does not survive this investigation.

A. D. Norris.

Huntington, York.

[1] Johnston, Longuet-Higgins and Ogston, *Trans. Faraday Soc.*, 588 (1945).
[2] D.Phil. Dissertation, accepted March 1944.
[3] Bull, "Advances in Enzymology", 1 (1941).
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Migration of Acyl Groups from Side-chain Nitrogen to Nuclear Carbon

The Claisen and Fries rearrangements embody the migrations of alkyl and acyl groups respectively, from oxygen of the side-chain to carbon of the aromatic nucleus. Where nitrogen occupies the position of oxygen in the foregoing side-chain, the migration of alkyl to the nucleus is again a familiar rearrangement (Hofmann–Martius), but the movement of acyl groups from side-chain nitrogen (parallel to the Fries reaction in the phenol system) is not so well known.

The work which has been done in this direction is mostly fragmentary, but it has led to the conclusion that migration can occur in the diacyl anilines[1]. With monoacyl anilines migration is more difficult to bring about and, apart from an unconfirmed claim by H. Meyer and Hofmann[2], it was not until recently that the rearrangement of acetanilide was established. By heating a melt of the anilide with aluminium chloride, Kursanov[3] obtained a 12 per cent yield of *p*-aminoacetophenone, and about the same time a similar observation was made by us, although we obtained a somewhat larger yield of the *p* aminoketone and also identified the *o*-amino isomeride as a product. We have now obtained a similar result with propionanilide, and the investigation is being extended to further monoacylated amines.

J. F. J. Dippy.
J. H. Wood.

South-East Essex Technical College,
Dagenham.
Mining and Technical College,
Wigan.
Nov. 12.

[1] Notably Chattaway, *J. Chem. Soc.*, **85**, 386 (1904).
[2] *Monats.*, **26**, 707 (1915).
[3] *J. Gen. Chem. Russ.*, **13**, 286 (1943).

Hydrogen Overvoltage as a Factor in the Corrosion of Metallic Couples

In their communication under the above heading, Messrs. Le Brocq and Cocks[1] redirect attention to a point that has been too often overlooked: namely, that the effectiveness of a metal as the cathode in a bimetallic corrosion system where hydrogen is evolved is dependent more upon the hydrogen overvoltage characteristics of the metal than upon its equilibrium single-potential in the electromotive series.

I have illustrated the general relationships between the cathodic and anodic potentials and the corrosion currents in bimetallic systems by a graphical method of potential/current diagrams[2], which is an extension of the method originally given by Evans[3], and used with modifications by Pourbaix[4] and by Wagner and Traud[5], for a single corroding metal. The special case cited by Messrs. Le Brocq and Cocks—the small acceleration of magnesium corrosion caused by contact with mercury, and the relatively considerable acceleration caused by contact with zinc—may be illustrated by the method as in Figs. 1 and 2. In Fig. 1, the lines C_{Mg} and A_{Mg} are the respective polarization curves of the cathodes and anodes on magnesium; they show the change of hydrogen overvoltage (assuming that the only cathodic reaction is hydrogen discharge), and the change in potential of the anode, with the current passing. If we neglect electrolytic and metallic resistance, the point of intersection of the curves, P, represents the corrosion current, i, and the corrosion potential of the magnesium. When a mercury cathode is coupled to the magnesium, if we assume that to a first approximation the system is equipotential, the small cathodic current on the mercury surface (represented by the steep curve C_{Hg}, for a high-overvoltage cathode) may be added to that on the magnesium to give the total cathodic current at any potential, curve $C_{(Mg+Hg)}$. The anodic or corrosion current on the magnesium is now represented by i', and for a steep C_{Hg} curve, it is only slightly

[1] Le Br
[2] Hoar,
[3] Evan
[4] Pourb
[5] Wagn
[6] Gatty

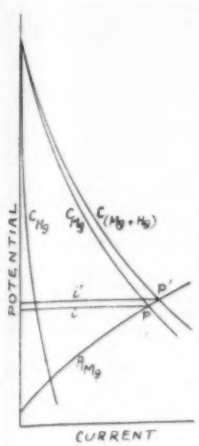

Fig. 1.

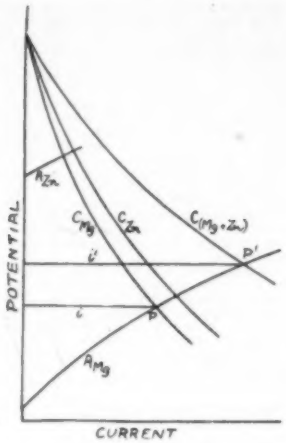

Fig. 2.

greater than i. In Fig. 2, the corresponding case for a zinc-magnesium couple is shown. Here, the much less easily polarizable (low-over-voltage) zinc cathode, curve C_{Zn}, causes a relatively large increase in magnesium corrosion.

In both the above cases, the anodic polarization curves representing the metal dissolution of mercury and zinc respectively—the positions of which depend on the single electrode potentials of the metals—do not need to be considered, because the corroding potential of magnesium is so much less noble (of the order of $-1{\cdot}2$ to $-1{\cdot}5$ v. on the hydrogen scale[5]) than even the equilibrium single potentials of mercury and zinc ($E_H°$, $+0{\cdot}799$ and $-0{\cdot}762$ v. respectively). For metal couples where the two anodic curves are close together, we may sum these in the same way as the cathodic curves and obtain a graphical representation of the more complicated case where anodic and cathodic reactions occur on both metals simultaneously. We may also make allowance for the resistance of the circuit where this is not very small, as here assumed. These constructions and others showing (*a*) the conditions at a pore in a metal-on-metal coating, (*b*) the reason why cadmium ($E_H° = -0{\cdot}402$ v.) is usually *anodic* towards iron ($E_H° = -0{\cdot}440$ v.) under corrosive conditions, are given in my original paper. The yet more complicated case of trimetallic systems—important in practice where, for example, a zinc protector is used to counteract the harmful action of a cathodic metal in a couple—may also be usefully treated along the same lines; I hope to elaborate this matter elsewhere.

The remark by Messrs. Le Brocq and Cocks that presence of oxygen reduces hydrogen overvoltage may perhaps be more accurately stated: oxygen at a cathode diminishes the total cathodic polarization at any given current-density, by providing the alternative *net* cathodic reactions

$$\tfrac{1}{2}O_2 + H_2O + 2e \rightarrow 2OH^- \text{ or } \tfrac{1}{2}O_2 + 2H^+ + 2e \rightarrow H_2O,$$

which begin at more noble potentials than the reduction of H^+ to H_2. At an oxygen-reduction cathode, there need be no intermediate formation of H or H_2.

T. P. HOAR.

Metallurgical Laboratories,
Cambridge.
Nov. 16.

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[4] Pourbaix, M., *Chim. Ind.*, **41**, 110c (1939).
[5] Wagner, C., and Traud, W., *Z. Elektrochem.*, **44**, 391 (1938).
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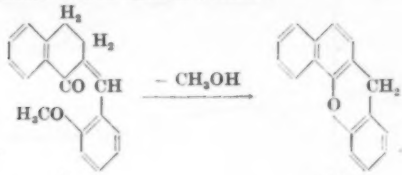
3 : 4-Benzxanthene

o-METHOXYBENZALDEHYDE condensed with α-tetralone in alcoholic potassium hydroxide to give 2-(*o-methoxybenzylidene*)-*α-tetralone*[1] (I) in faint yellow plates, m.p. 110–111°. When (I) was refluxed with phosphorus pentoxide in xylene for twenty hours, it gave in a poor yield a colourless product (II), m.p. 91–92°, thought to be 8-methoxy-3 : 4-benzfluorene. (II) gave in absolute alcohol a red picrate, m.p. 125–126°.

This compound (II) can be obtained in a much better yield by heating (I) with a fused mixture of potassium hydrogen sulphate and sodium sulphate at 260–270° for three quarters of an hour.

Analysis showed that (II) contains neither methoxyl nor hydroxyl groups. This was supported by the fact that it was insoluble in alkalis and was recovered unchanged on being refluxed with hydriodic acid (d., 1·96) in glacial acetic acid for five hours. It was easily oxidized by different oxidizing agents (selenium dioxide, cold or hot sodium dichromate or potassium permanganate in acetic acid, alkaline potassium ferricyanide and cold chromic acid in acetic acid) to give the same colourless product, m.p. 161–162° (III). This cannot be a 3 : 4-benzfluorenone, as all these compounds are coloured. On drastic oxidation of (II) with a boiling solution of chromic acid in glacial acetic acid, an orange-red compound, m.p. 348°, insoluble in most organic solvents, was obtained; this compound is under investigation.

We found that the melting point and the physical properties of (III) resembled those of 3 : 4-benzxanthone. This identity was ascertained by the fact that no depression of the melting point was observed on admixture with an authentic specimen[2].



(I) (II)

This shows that ring (I) closed under the influence of phosphorus pentoxide or the pyrosulphate, with the elimination of methyl alcohol, to give 3 : 4-benzxanthene (II), which gave on oxidation 3 : 4-benzxanthone (III).

This new method is now applied for the synthesis of substituted 3 : 4-benzxanthenes.

FAWZY GHALI BADDAR.
MUNIR GINDY.

Fouad I University,
Abbassia, Cairo.
Nov. 11.

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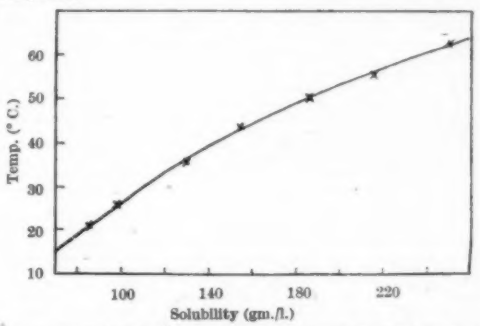
Solubility of Pyrocatechol in 1, 2, 4-Xylenol

LOCAL deposits of lignite were worked up under the Germans by low-temperature carbonization and subsequent hydrogenation of tar by means of converted water gas. The water which formed in the course of this process was extracted for phenols and other organic substances by means of isobutyl acetate and the extract worked up by distillation. Phenol and the cresols were obtained in an impure state, the heavier phenolic substances being returned to the hydrogenation process.



In an attempt to obtain pyrocatechol in a pure form it was found that it could only be recrystallized with considerable loss from benzene, but that we had at hand a more efficient solvent in the mixture of xylenols constituting the fraction which distilled before pyrocatechol.

The solubility of pyrocatechol in 1,2,4-xylenol (Merck) was measured and expressed in the accompanying graph. The presence of homo- and isohomo-pyrocatechol does not interfere. Pyrocatechol crystallizes in small plates of a melting point of 102–103° C.

A paper on the composition and separation of the above-mentioned mixture of phenols is in preparation.

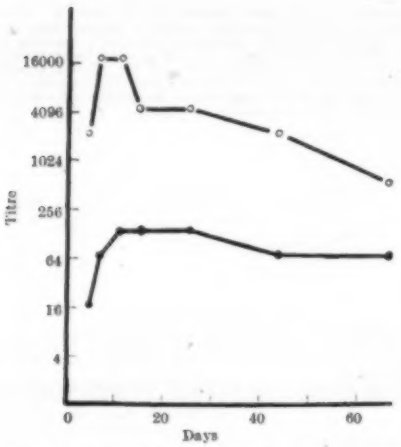
W. LOWENSTEIN.

Czechoslovak Works for the Manufacture of Synthetic Fuels,
By-products Department,
Zaluzi, near Most,
Czechoslovakia.
Dec. 1.

Rh Blocking Antibodies

THE detection of *Rh* sensitization in a patient often depends on the detection of *Rh* antibodies. *Rh* agglutinins are most commonly sought, but in certain cases where *Rh* sensitization is anticipated they are not found. In some of these sera, 'incomplete'[1] or 'blocking'[2] antibodies are found.

A mother received 1,000 c.c. of *Rh*-positive blood and was subsequently delivered of a stillborn child affected with congenital hydrops. Samples of blood were first obtained on the fifth day after transfusion. The mother was *Rh*-negative. The maternal serum was examined



●, blocking; ○, 'conglutination'. Blood transfusion at 0 days.

and *Rh* agglutinins were detected in the first two samples, although there was marked zoning. The samples of serum were preserved since 1943 at − 20° C., and later titrated for blocking antibodies (using an anti-Rh_0 test serum titre 1 : 16) and by the 'conglutination' method[2]. The results are shown in the accompanying graph. The two curves are roughly parallel, but do not show a marked peak; this may in part be due to the time elapsing between the examination of samples. The persistence of a high-titre blocking antibody for a long period is shown, since after 18 months it was still 1 : 8.

Rh agglutinins have been known to persist in maternal sera for twelve or more years. In the case cited above, blocking antibodies of titre 1 : 4 were detectable 2½ years later; in another instance they have been known to persist for 18 months.

In 1942 a serum was examined which was known to react with cells eventually classed as Rh_1 and failed to react with Rh_2 type, in fact an anti-Rh_2 serum. Blocking antibody was detected in this serum but was only weakly present in the last sample obtained three months after birth of the affected child. In 1944 a further specimen of maternal serum (there having been no intervening pregnancy) was examined and found to be of anti-*Rh'* variety. This latter serum had a titre of 1 : 16 with the Rh_2 donor's cells with which the 1942 sample failed to react. Blocking activity seems to have disappeared from the serum revealing the presence of anti-Rh_1 agglutinins. This confirms the specificity of the blocking antibodies here as anti-Rh_2. That these antibodies have this action is put to practical use in preparing specific anti-Rh_1 and anti-Rh_2 typing sera from the commoner anti-*Rh'* and anti-*Rh"* varieties. The suppression of agglutinating activity may be due to the more rapid and complete reaction between the blocking antibody and the antigen, but this is probably not the whole explanation.

Baar[4] has described the presence of blocking antibodies in the blood of babies affected with hæmolytic disease. I have seen a child affected with congenital hæmolytic anæmia whose blood, examined on the eighth day after birth, was found to have erythrocytes which failed to react with anti-Rh_1 serum. A strong agglutination reaction was given using an anti-Rh_1 typing serum and a negative one with anti-Rh_2 serum. The cells thus appeared to be of type *Rh'*. Re-examination of this child's erythrocytes at the age of 18 months showed them to be of type Rh_1, giving a strong reaction with the anti-Rh_1 typing serum. The maternal serum contained strong *Rh* blocking antibodies on both occasions. Wiener[4] mentions this phenomenon, but this is the only case I have so far observed, though this may be accounted for by the high-titre anti-Rh_2 typing serum (1 : 2,000) used as a routine.

Eight other samples of blood from babies affected with hæmolytic disease have recently been tested for blocking antibodies by the original method[1,5]; one case gave a positive and two doubtful results.

The sample of blood containing blocking antibodies was obtained from an affected child 24 hours old. There were no *Rh*-agglutinins in the child's serum, but it gave a positive 'conglutination test'. The erythrocytes were of Rh_1 type and reacted strongly with anti-Rh_1 serum. The erythrocytes were washed with saline and added to a serum from a group *AB* mother and containing Rh_2 blocking antibodies. The erythrocytes were allowed to remain in contact with the serum at 37° C. for 30 minutes. They were then separated and washed with saline. These treated babies' cells now failed to agglutinate when mixed with an anti-Rh_2 typing serum. Moreover, the cells before treatment gave a positive Coombs-Mourant-Race test (*vide infra*), but after treatment this was very strongly positive.

The evidence in this particular case points to the infant's cells being incompletely saturated with Rh_2-blocking antibody whereas this latter was present in its own blood. It must be remembered, however, that the blocking antibodies in the child's blood were difficult to detect and much weaker than those normally encountered in maternal sera.

Coombs, Mourant and Race[5] introduced a test for *Rh*-sensitivity by detecting globulin absorbed on to erythrocytes with an anti-human globulin precipitin serum. Using this test on the blood of seven of the eight children affected with hæmolytic disease referred to above, all seven babies' erythrocytes gave positive results. (The reagent was kindly supplied by Dr. Race.) By the use of this test and the 'conglutination test', information will be obtained concerning the affected child's blood which will be of value in the diagnosis and treatment of hæmolytic disease of the newly born.

F. Stratton.

Regional Transfusion Service,
Royal Infirmary, Manchester, 13.

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Rh Antigens and Antibodies in Man

A 'new' *Rh* antibody has recently been found[1] which has made possible the recognition of a third allelomorph at Fisher's *C*−*c* locus[2]. The antibody has been produced by a hypersensitive recipient of blood transfusions. A detailed account of this case is in the press[3]. The antibody is being called anti-C^w and the corresponding gene or antigen C^w. *W* stands for Willis, the name of the donor whose blood stimulated the formation of the antibody. Any remaining doubt as to the appropriateness of recognizing three loci seems to be removed by this finding.

The frequency of the three allelomorphs in England is: *C*, 43 per cent, *c*, 56 per cent and C^w, 1 per cent. C^w can be combined with *D* or *d* and *E* or *e* in four ways, two of which have been observed, namely, C^wDe and C^wde. That is to say, two more *Rh* 'allelomorphs' or, more properly, combinations of genes have been added to the seven previously found. A further two, C^wDE and C^wdE, may be assumed to exist, though both must be rare.

A result of finding the new antibody has been the recognition that about half the sera formerly classified as anti-*C* (anti-*Rh'*) are in fact mixtures of anti-*C* and anti-C^w, the remainder being pure anti-*C*. (Both types may contain the 'incomplete' or non-agglutinating form

Table 1.

	Anti-*Rh'* sera 'anti-*C*'				
	anti-*c*	50% anti-*C*	50% anti-*C* + anti-C^w	anti-C^w	frequency
C^wC^w	−	−	+	+	0·01 per cent
C^wC	−	+	+	+	0·94 ,,
CC	−	+	+	−	18·40 ,,
C^wc	+	−	+	+	1·23 ,,
Cc	+	+	+	−	48·05 ,,
cc	+	−	−	−	31·36 ,,
					99·99 ,,

Table 2.

Antibodies	Genes and antigens										
	R_0 *cDe*	*r* *cde*	R_1 *cDE*	*R"* *cdE*	R_1 *CDe*	*R'* *Cde*	R_2 *CDE*	R_{Z} *CdE*	C^wDe	C^wde	C^wDE	C^wdE
Anti-*C*	−	−	−	−	+	+	+	(+)	−	−	(−)	(−)
Anti-*D*	+	−	+	−	+	−	+	(−)	+	−	(+)	(−)
Anti-*E*	−	−	+	+	−	−	+	(+)	−	−	(+)	(+)
Anti-*c*	+	+	+	+	−	−	−	(−)	−	−	(−)	(−)
Anti-*d*	(−)	(+)	(−)	(+)	(−)	(+)	(−)	(+)	(−)	(+)	(−)	(+)
Anti-*e*	+	+	−	−	+	+	−	(−)	+	+	(−)	(−)
Anti-C^w	−	−	−	−	−	−	−	(−)	+	+	(+)	(+)

The left upper compartment shows the interactions known before Fisher's theory was postulated[2]. The middle compartment shows the extension demanded by Fisher's hypothesis, now in part confirmed serologically. The right and lower compartment shows the extensions made and those suggested by the anti-C^w serum. Reactions which have not yet been confirmed serologically are shown in brackets. In this table anti-*C* means pure anti-*C* and not anti-*C* + anti-C^w which, as already mentioned, is the constitution of about half the anti-*Rh'* sera.

of anti-*D*.) This finding provides the explanation of occasional discrepancies of behaviour between different anti-*Rh*′ sera which have been noted during the last two years.

The possible combinations of *C*, *c* and C^w in a pair of chromosomes, the calculated frequency of these combinations in England and the reactions which they determine, are shown in Table 1. All these combinations have been observed.

Although homozygous C^wC^w blood is very rare in the general population, one example has been found. One daughter of a mating $C^wDe/cde \times C^wDe/CDe$ was C^wDe/C^wDe. Another daughter of this mating was heterozygous, C^wDe/CDe. The C^w homozygous blood gave a much stronger reaction on titration against the anti-C^w serum than does heterozygous blood; a dosage effect which is also noted with the agglutinins anti-c^g and anti-c^t. The antigens *C*, *D* and *E* only show a slight dosage effect which is difficult to demonstrate.

The chart of the *Rh* antigen – antibody interactions, recently published in these columns[1] can now be extended (Table 2).

The 45 genotypes to which the nine known *Rh* 'allelomorphs' give rise can be divided into 24 serologically distinguishable groups. Considering the *Rh* groups together with the blood groups of the A_1A_2BO, *MN*, *P* and 'Lutheran' systems (but ignoring the Levay group as it is extremely rare) there are 1,728 combinations which could be recognized serologically in individuals. These represent 18,225 possible genotype combinations.

R. R. Race.
A. E. Mourant.
Sheila Callender.

Medical Research Council,
Emergency Blood Transfusion Service;
and Nuffield Department of Clinical Medicine,
Oxford.
Jan. 10.

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Incidence of the *Rh* Factor in Indians

Levine[1] has shown that the incidence of erythroblastosis fœtalis in any race is directly proportional to the frequency of negative reactions with anti-*Rh*, serum. Racial differences in the incidence of *Rh* agglutinogen have already been described, and clinical observations have confirmed the existence of a close correlation between the distribution of the *Rh* factor and the frequency of hæmolytic disease of the newborn.

In India there have been no reports of the occurrence of hæmolytic disease of the newborn, even during the last few years after the discovery of the *Rh* factor by Landsteiner and Wiener[2]. Similarly, reports are lacking of hæmolytic transfusion reactions due to *Rh* iso-immunization.

The number of blood transfusions given in India is much smaller than in other countries, for example, England or the United States, and the number of patients receiving multiple blood transfusions, fewer still. This might perhaps explain in part the lack of reports of hæmolytic transfusion reactions due to iso-immunization against the *Rh* factor.

The poor antigenicity of the *Rh* antigen may be another factor. DeGowin[3] has shown that iso-immunity against the *Rh* factor was the cause of hæmolytic transfusion reactions in only 0·1 per cent of 5,386 consecutive transfusions given to recipients without regard to the *Rh* type or obstetric history of female patients. In a group of 1,717 recipients who received from one to three transfusions, none was sufficiently sensitized to the *Rh* factor to give clinically significant reactions.

No satisfactory explanation has been forthcoming to account for the non-occurrence of erythroblastosis fœtalis in India. It was therefore considered of interest to study the incidence of the *Rh* factor in the population.

Lack of *Rh* typing serum and of known *Rh* positive and *Rh* negative bloods was the initial difficulty. Anti-*Rh* sera produced by immunization of laboratory animals against Rhesus monkey cells have not been satisfactory in our hands. We were able to obtain a supply of immune human anti-*Rh*, serum from England. One hundred and forty-five specimens of blood from an unselected population, most of them blood donors, were examined. Of these 123 were from Hindus, 13 Muslims, 8 Indian Christians and one Anglo-Indian. There were 139 (95·9 per cent) *Rh* positives and 6 (4·1 per cent) *Rh* negatives, the latter being all Hindus.

There are significant differences in the published figures relating to the distribution of the *Rh* factor in Indians. Greval and Chowdhury[4] place it at 90 per cent at Calcutta, while Khanolkar and Sanghvi[5] have reported a frequency of 98 per cent *Rh* positives in Bombay. The figure for the present series is 95·9 per cent. It is probable that the above differences are due to the small number of bloods examined in each series. Further, the Calcutta workers employed immune animal serum for *Rh* typing. It will be necessary to examine some thousands of bloods with reliable anti-*Rh* typing sera before statistically accurate figures can be obtained. Nevertheless, the above findings suggest the probability of a higher incidence of the *Rh* factor in Indians than in white individuals, and a lower one than that in the Chinese and the Japanese. They would also appear to suggest that erythroblastosis fœtalis may not be so rare in Indians as it is supposed to be. It is now known that immunization of even an *Rh* positive person can occur, and a person of one *Rh* subgroup can form antibodies against the antigen of another subgroup. A factor favourable for the causation of hæmolytic disease of the newborn in Indians is the large number of children born in each family. This may be expected to offset to some extent any tendency to low frequency of hæmolytic disease of the newborn, due to a higher incidence of the *Rh* factor in the population.

A systematic investigation of all cases of suspected hæmolytic disease of the newborn, unexplained stillbirths, hæmolytic transfusion reactions, etc., would appear to be called for in order to prove beyond doubt the occurrence or otherwise of clinical manifestations of iso-immunization against the *Rh* factor.

Our thanks are due to Dr. G. L. Taylor, of the Galton Laboratory Serum Unit, Cambridge, and to Dr. Janet M. Vaughan, for the supply of anti-*Rh* sera, and to Dr. C. G. Pandit, director of the King Institute of Preventive Medicine, Guindy, Madras, for permission to publish this note.

K. S. Ranganathan.
C. S. Ramachandra Rao.
N. R. Ratnakannan.

Madras Blood Bank,
King Institute of Preventive Medicine,
Guindy, Madras.
Nov. 29.

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Rh-negative Rate for Indians

The *Rh*-negative rate for Indians in our first series of 200 cases in Calcutta was 10 per cent[1]. In a second series it fell to 7·85 per cent[2]. Wiener's[3] rate in a series of 200 cases is 7·1 per cent. This rate contains all types of *Rh*, including 2·6 per cent *Rh*′, which would be missed by animal/(anti)serum. By the use of the latter serum alone, therefore, the rate would be 9·7 per cent, which is not materially different from our first rate.

The rate of Khanolkar and Sanghvi[4], at least the one based on the findings in 70 Hindus and 5 Muslims none of whom was found to be *Rh*−, is materially different: 14 Parsees—possibly an ethnological group—and 11 Indian Christians—definitely not an ethnological group—gave one *Rh*− subject in each group. These workers admit the difference, but impute it to the animal serum used by us. We justify the use of our serum on the following grounds: (1) The *Rh* antigen is named after the brown monkey *Macacus rhesus* in the red blood corpuscles of which it is found. Its presence in man was and could only be determined by an animal antiserum prepared against the red blood corpuscles of the monkey. (2) The serum was compared with the same human serum with which Khanolkar and Sanghvi worked (standard, anti-Rh_0 serum, supplied by the late Dr. George Taylor and brought to India by Dr. Janet Vaughan). Of 54 cases tested with both the human serum and the animal serum, 5 were found to be negative. As the human serum came from group *A* and the subjects tested also belonged to group *A*, the question of over/under absorption of the co-existing iso(hæmagglut)nin did not arise. Incidentally, none of the human anti-*Rh* sera (for detecting Rh_0, Rh_1, Rh_2 and *Rh*′, according to nomenclature used by Taylor on October 26, 1944) showed a particular affinity for the red blood corpuscles of the monkey.

We use both slides and test tubes, and the two sets of results agree on the whole. Incidentally, at least one other team of workers[5] has found the slide satisfactory. The use of the slide and the test tube, and the preparation and appropriate dilution of animal serum, will be discussed elsewhere.

The animal serum yields a certain percentage of doubtful, ±, reactions which we include with +. A suggestion, however, emerges: ± reactions (with animal sera) should be taken as + for a donor but as − for a recipient, in transfusion of blood.

As in Bombay, cases of erythroblastosis fœtalis have not yet been found in Calcutta (population three millions), although a lookout has been kept since 1943. The reason may be the absence of chilling, which presumably also lowers the incidence of paroxysmal hæmoglobinuria in Calcutta to 0 (no case has yet been seen by the senior writer, who first made his request to the clinicians for contacting one in 1934).

On the data so far available, we are inclined to think that the *Rh*− rate for Indians lies between 7 and 10 per cent. Going by the incidence of A_1 and *Rh*− rate, Wiener[3] puts Asiatic Indians among Caucasian races.

Incidentally, *Rh* is a 'character' genetically and an 'antigen' immunologically: 'factor', essentially a mathematical term, is scarcely necessary. (Factors in physiology—for constituents, fractions, parts, etc.—are equally unnecessary.) We determine the *Rh*+/− state of a subject, not his *Rh* factor.

S. D. S. Greval.
A. B. Roy Chowdhury.

Laboratory of Imperial Serologist and
Chemical Examiner to the Govt. of India,
School of Tropical Medicine,
Calcutta.
Dec. 29.

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Whale Stocks and Whaling

Norsk Hvalfangst-Tidende, now in its thirty-fourth year, is the official organ of the Norwegian Whaling Association. It is a current history of whaling and publishes information on all branches of the subject.

I have begun to receive it again and would refer to an article in the August number (p. 117) entitled "Shipping, Whaling and the Supply of Fats". In it, *Shipbuilding and Shipping Record* of August 23, 1945, is stated to have printed a report on post-war policy from the Whaler Section of the Chamber of Shipping of the United Kingdom which had been presented to the Ministries of Food, Agriculture and War Transport, and contained the following statement: "The unique advantage of whaling as a major source of food production to meet the urgent needs of the post-war period lies in the fact that the stock of whales has increased considerably in the years since 1939–40, during which practically no whaling operations have been carried out", and goes on at length with discussion of outfitting factories.

The editorial comment (p. 119) referring to this passage states that, "What is said about the considerable increase of the stock of whales we fear is a too optimistic view. One must take into consideration that the taxation of the whale stocks during the last three seasons before the war was very heavy. . . . In spite of the big increase in the number of expeditions and catcher boats the total production decreased very considerably in the last season, namely, from 3,340,300 barrels in 1937/38 to 2,820,771 barrels in 1938/39. . . . This was a very grave danger signal, and it was obvious that it was the result of a taxation of the whale stocks far too high. . . . That it would take time before the wounds were healed again was very likely, and although the whale stocks in Antarctic waters have enjoyed a good holiday during the wartime, reports from the catching field prove that no considerable increase has taken place. . . . The manager of the floating factory 'Sir James Clark Ross' which operated in the Antarctic season 1944/45 says that in his opinion he could not say that there were more whales now than before the war, but that the whales were not so shy as they had been."

The editorial comment ends with correction of the figures for average world production of oil and number of expeditions working for six years to 1939–40.

I do not propose to offer comment on the disagreement between the journals, but I feel that it should be more widely known.

While considering the future of whaling, I would point out that the present minimum killable lengths set forth in the International Agreement on Whaling are *less* than the lengths at which whales become sexually mature and are therefore of little or no use for preserving the stock.

It is certain they ought to be revised, and the whalers themselves should consider the matter in their own interests.

	Average length at sexual maturity[1]	Minimum killable[2]
Blue Whale, male	74 ft.	70 ft.
" " female	77 ft.	
Fin " male	63 ft.	55 ft.
" " female	65 ft.	
Humpback Whale, male	39 ft. 4 in.	35 ft.
" " female	41 ft.	

I suggest that, valuable as it may be at the moment, it would be unwise to regard whales as a permanent source of great quantities of meat and oil.

Having regard to the history of all whaling in the past, it seems reasonably probable that the supplies are likely to diminish with perceptible rapidity, even if the results of the first season are highly satisfactory from the point of view of the whalers.

J. E. HAMILTON.

Stanley,
Falkland Islands.
Dec. 14.

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Mixed Iodophile Populations of the Human Colon and Cæcum

SINCE attention was first directed to the subject by Henneberg[1], the role of iodophile micro-organisms in the decomposition of starch, cellulose, and other carbohydrates, taking place in the gut diverticula of herbivores, has been repeatedly confirmed[2]. The biochemical and microbiological investigations of Pearson and Smith[3], and Smith and Baker[4], have also shown that in the ox such micro-organisms may afford a major contribution to the synthesis of protein from non-protein nitrogen occurring in the rumen.

In view of these facts and of the results of recent researches upon the microbial synthesis of vitamins in the gut[5–10], the demonstration in the human colon and cæcum of an abundant iodophile population similar to that of herbivores acquires significance. The material used was collected from colostomy and other cases, and was formalized immediately. Direct microscopical examination of the material, according to methods elaborated by Baker and Martin[11], and Baker[12], disclosed iodophile bacteria in large numbers in the interior and upon the surfaces of plant structures. A specific relation to the decomposition of the vegetable material was indicated by the absence of micro-organisms from the surfaces of intact or partially digested muscle-fibres also present in the ingesta. The iodophile types included giant clostridia, giant diplococci, slender vibrios, small rods and cocci. Preliminary observations made under the polarizing microscope suggest that some of these iodophile organisms are able, as in herbivores, to attack true cellulose.

This fact, if confirmed, must acquire interest in connexion with the assertion, which has been repeatedly made[13–15], that in certain subjects the capacity of the human colon to digest cellulose, which is normally low, may be markedly augmented. That any intrinsic benefit can thereby ensue is altogether questionable. Indeed, an adverse influence has been associated with the condition[16], owing to the constipation and dyschezia which may result from an abnormal reduction in the bulk of the faeces. The possibility, however, of a positive or negative relation between such changes in the relative density of the normal microbial population of the colon and cæcum, and the ability or failure to synthesize particular vitamins, cannot be ignored. Further investigations upon the capacity of the iodophile micro-organisms mentioned to utilize polysaccharide substrates are in progress in this laboratory.

FRANK BAKER.
(Plimmer Research Fellow.)
SUSAN PALMER.

County Technical College,
Guildford.
Nov. 14.

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Hatching of the Egg of *Ixodes ricinus* L.

DURING the course of an ecological investigation, we have had abundant opportunity for observing eggs of *Ixodes ricinus* L. A recent communication[1] on the mechanism of the hatching process raises some points of interest.

Reference is made to the appearance, in eggs maintained at 60° F. and 80 per cent relative humidity, of an extensive white dumb-bell shaped area, which is evident between twenty-one and thirty days after oviposition. Mr. Arthur does not indicate whether this was observed in living eggs or in preserved material, and consequently, it is difficult to decide to what structure the description refers. We assume the area in question to be the sac formed at the junction of the Malpighian tubules with the gut, which when distended with excretory material becomes a distinct white structure readily visible in living eggs. If this interpretation be correct, we would suggest that the time limits stated, for the given temperature conditions, are much shorter than in our observations. Although the species exhibits a wide degree of variation in all its developmental time-relations under any given set of environmental conditions, we consider that thirty-five to forty days would be a minimum for the appearance of this structure at 60° F.

Mr. Arthur describes a reflexion of the larval head for a period of 7–10 days after hatching. We have never observed this condition in healthy larvæ at any time subsequent to emergence, where they have been reared at temperatures between 14° and 22° C., and at or near saturation vapour pressure. The mouthparts of newly emerged larvæ are directed forwards, and may be depressed ventrally at an approximate angle of 30° to the longitudinal axis; and a slight ventral depression frequently persists in mature larvæ. When eggs are subjected to unfavourable conditions, for example, above 25° C., a typical abnormality encountered in those individuals which survive and hatch is a persistence of the embryonic dorso-ventral curvature of the whole length of the body. In these cases the mouthparts are not visible from the dorsal aspect. In our experience, 80 per cent relative humidity is a condition at which a considerable mortality occurs, and we suggest the possibility that reflexion of the head may be an abnormality associated with this extreme environmental factor.

At the time of hatching, the excretory sac is charged with waste products, and the newly emerged larva continues to discharge the contents over a period of several days until the sac is completely emptied. Elimination of excretory products usually begins at the time of hatching, and frequently a quantity of the waste material remains in the eggshell. After emergence, the gut exhibits a well-defined series of changes, simultaneously with the processes of excretion, and hardening of the chitinous integument. In the newly emerged larva, the gut frequently appears as a simple sac charged with vitellus. Within 7–10 days, the remaining vitellus is largely digested, and the gut assumes its typical lobed aspect.

J. ALLAN CAMPBELL.

Department of Agricultural and Forest Zoology,
University of Edinburgh.
Nov. 22.

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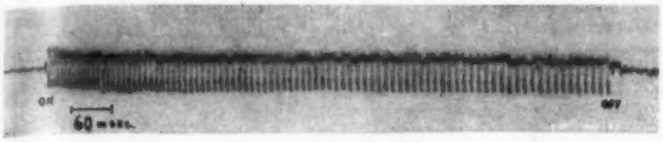
Repetitive Discharge of Giant Nerve Fibres of the Earthworm

IN experiments on the electrical stimulation of the nerve cord of the earthworm, we have obtained a repetitive discharge of the dorsal giant fibres on stimulation of the isolated intact cord by a constant direct current. So far as we are aware, this has not been described previously in the earthworm. There is no mention of it in the four papers known to us dealing with the electrical activity of the dorsal giant fibres[1–4] of this annelid.



REPETITIVE RESPONSE OF THE GIANT FIBRES TO A CONSTANT DIRECT CURRENT OF 20 μA., APPLIED AT THE HEAD END OF THE ISOLATED NERVE CORD OF THE EARTHWORM. RECORDING ELECTRODES WERE PLACED ON THE CENTRAL PORTION OF THE CORD.

We find a rapid repetitive firing, often sustained for the whole time that the current is maintained (for example, 1 sec.), as shown in the accompanying figure. The response shows slow accommodation: initial rates up to 330 impulses per sec. have been observed, diminishing to 10–50 per sec., but this latter rate varies widely from one preparation to another. The repetitive burst may contain as many as a hundred spikes. Current intensities of 5–20 μA. are adequate to evoke the response from the isolated cord, stimulated through fluid electrodes with a contact area of 1–2 sq. mm. and interpolar distances of 5–15 mm. Transmission of this repetitive response in the dorsal giant fibres is abolished, reversibly, by solutions of potassium chloride, of strength 0·5–2·0 per cent (made up in a 66 per cent mammalian Ringer fluid).

V. E. Amassian.
W. F. Floyd.

Department of Physiology,
Middlesex Hospital Medical School,
London, W.1.

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Influence of a Decreasing Rainfall on *Physopsis africana* Krauss

Not since 1933 has the annual rainfall in Natal approached the low figure of the last two years except in 1941, and more than half the annual total for 1945, namely, 27·1 in. up to December 26 (when some rains started), fell in the months of February and March.

There has been a steady disappearance of pond-snails and allied wild life for the last thirty years, and river trout have largely disappeared from parts of the country; but *Physopsis africana* Krauss has shown a resistance to environmental influences which have proved detrimental to its natural enemies. Specimens of this shell have remained in river-pools for an abnormally long period, and may now be collected from the open river measuring twenty millimetres in length, though 18·8 mm. was regarded as the maximum length for the shell in even sheltered pools in former years.

These larger specimens are free of larval trematodes and suggest that it is not until rains have washed human pollution off stones in the river-beds and bathing becomes frequent that infestation occurs.

F. Gordon Cawston.

Britannia Buildings,
Durban.
Jan. 14.

Adrenocorticotrophic Activity in Urine from Pregnant Women

During the past few years repeated attempts have been made to isolate, from the urine of pregnant women, pituitary anterior lobe hormones or substances with activities similar to those of the pituitary anterior lobe hormone, other than chorionic gonadotrophin.

The different extracts have all been tested on hypophysectomized rats, so that any unspecific extraction product stimulating the endogenous pituitary hormone production could be excluded. The morphological changes of the atrophic thyroid were used for the determination of thyrotrophic hormone. For testing the presence of corticotrophic hormone, the resultant changes of the sudanophobic zone were investigated[1].

The first experiments, in which only unconcentrated urines were used, did not give any result. Experiments in which adsorption to benzoic acid was tried were equally negative.

In a later series of experiments, mixed pregnancy urine acidified to pH 5 was precipitated by an equal amount of saturated picric acid. The precipitate was extracted with slightly ammoniacal water (pH 8) and the filtered solution was reprecipitated by ten times its volume of acetone. The acetone-dried precipitate showed not only gonadotrophic activity but also corticotrophic activity, while thyrotrophic activity was absent in all experiments.

One unit of gonadotrophic hormone was found in 0·1 mgm. of the dried powder. One unit of corticotrophic hormone was found in 3–4 mgm. of the powder; while 12 mgm. of the powder failed to show any thyrotrophic action.

Ten litres of mixed pregnancy urine worked up with the picric acid procedure yielded an average of 1·4 gm. of powder. This means that from one litre of the mixed urine sample an average of 35 units of corticotrophin, or corticotrophin-like hormone, could be isolated. The identity of this compound with the corticotrophic hormone isolated from the pituitary anterior lobe has not yet been established. It was only found to be equally thermostable.

Investigation of the presence of the corticotrophic substance in normal urines has, hitherto, shown considerably smaller values[2]. Blumenthal[3] has recently investigated the action of normal female human urine and of pregnancy urine on the number of mitoses in the adrenal cortex of guinea pigs, and found these mitoses significantly increased after the injection of unconcentrated urine.

Excluding the possibility of this action being due to the presence of unspecific adrenal cortex stimulating substances (the test animals were not hypophysectomized), one might assume an identity between the mitosis-stimulating substances and the substances which restore the sudanophobic zone of the adrenals of hypophysectomized rats. In view of the activity of corticotrophic hormone in increasing body resistance on one hand, and the increased resistance on the other hand of the pregnant organism against colds, infections and particularly against the toxic products of the growing embryo, the presence of corticotrophic hormone in the urine of the pregnant women is of interest in discussing the mechanism of the increased resistance of the organism.

Max Reiss.
Harold Peglar.
Y. M. L. Golla.

Endocrinological Department,
Burden Neurological Institute,
Bristol.
Dec. 4.

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Sodium/Potassium Ratio in the Coelomic Fluid of Insects

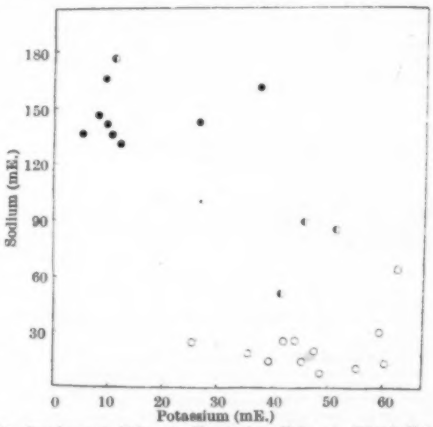
The ionic composition of the circulating fluids is very uniform throughout the animal kingdom: it shows especially a marked excess of sodium over potassium ions. The insects were the only supposed exception. According to the analyses of several authors[1], their coelomic fluid was thought to contain an excess of potassium, the Na/K ratio being less than unity.

Adapting microanalytical methods for sodium and potassium so as to work on such small quantities as 1 μl. of fluid, we analysed the coelomic fluid of twenty-four insects belonging to several orders.

The Na/K ratio appears to be highly variable among the insects, its value ranging from 0·11 to 26·0.

The supposed biochemical hiatus between the insects and the rest of the animal kingdom clearly does not exist: the problem, open to experimental analysis, emerges of the variation of ionic regulation among the members of a single zoological group.

The variation of the Na/K ratio shows no relation to taxonomy. A clear association with the alimentary diet of the insects appears from an examination of the accompanying graph.



●, Carnivorous diet; ○, Vegetarian diet; ◐, Mixed diet.

The vegetarian insects have in their coelomic fluid a predominance of the potassium ions over the sodium ions (Na/K < 1), while the reverse holds for the carnivorous insects, which thus have more sodium than potassium (Na/K > 1). The insects with mixed diet have, in general, an intermediate ratio.

Further investigations may elucidate the origin of the observed association: whether it results from an actual influence of the food or whether it is the present state of an evolutionary process acting along the history of the insect phylum.

Details will be published in the *Ann. Soc. Royale Zool. de Belgique*.

Georges J. Bonè.

Institut de Médecine tropicale,
Anvers.
Nov. 30.

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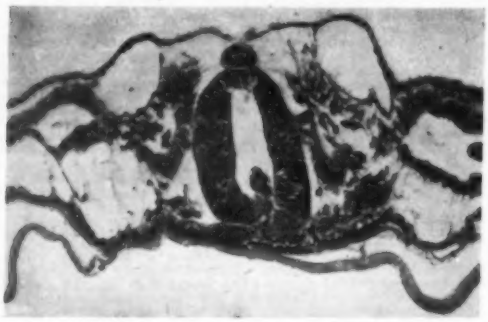
Influence of Sodium Thiocyanate on the Development of the Chick Embryo

UNINCUBATED eggs were injected with 0·3–0·7 ml. of sodium thiocyanate of various concentrations (0·1 *M*, 0·5 *M*, 1 *M*) and incubated for 42–47 hours. The embryos thus developed showed a number of anomalies, first of all in the prosencephalon and partly in the mesencephalon; the metencephalon and myelencephalon being, in general, not so much affected. One of the most frequently observed anomalies of the latter was due to the abnormal closing of the neural tube: it seems that one of the neural folds was growing more quickly, thus being overlapped by the other (see section). This anomaly extended in various cases to the middle of the myelencephalon. Further changes were observed in the position of the heart, which was displaced, in extreme cases, into the precephalic region. No morphogenetical changes of the somites were observed, though the number was lower (14–17) than that of normal embryos of the same age.



CHICK EMBRYO INJECTED WITH 0·3 ML. OF *M* SODIUM THIOCYANATE. INCUBATION FOR 42 HOURS. TRANSVERSE SECTION AT THE LEVEL OF THE FIRST SOMITE.

The question whether the notochord was hyperdeveloped is still not very clear: in some cases it was certainly folded, but it is difficult for us to decide at the moment whether this is due to the same cause as described by Ranzi[1] for the amphibian embryos.

In conclusion, we may say that sodium thiocyanate inhibits, but to various degrees, the growth of different organs. Here the heterauxesis[2,3] is particularly in evidence: for example, the brain in many cases corresponds to a much younger embryo than the number of somites would suggest. Even inside one and the same organ we found differences in the growth-rate, as noted above in the growth of the neural folds. The heart, in comparison with the rest of the body, also shows typical bradyauxesis.

From the morphogenetical point of view, sodium thiocyanate acts, first of all, on the brain. No definite influence, besides an inhibitory effect on the meso- and endoderm, could be observed.

Details, with biochemical analyses, will be published elsewhere.

WIKTOR W. NOWINSKI.
JOSÉ PANDRA.

Instituto de Anatomía General y Embriología,
Facultad de Ciencias Médicas,
Universidad de Buenos Aires.
Aug. 25.

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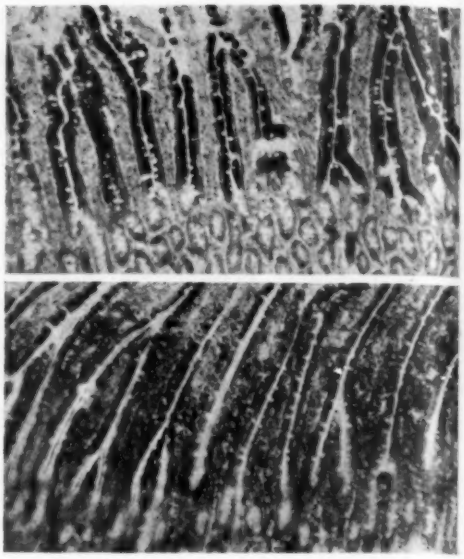
Effect of Choline on the Intestinal Absorption of Fat

THE effect of choline on intracellular fat in the liver and other organs has been extensively investigated. So far as we can discover, no experiments have been published on the effect of choline on the fat normally present in the intestinal cells during absorption.

Striking differences can be demonstrated between the distribution of fat in the intestine of rats fed 1 c.c. of olive oil and 1 c.c. of water and those fed 1 c.c. of olive oil and 1 c.c. of 0·5 per cent choline chloride. The difference can be seen in the accompanying photographs.

After olive oil and water, the cells are filled with large globules of fat and very little appears to have passed through into the areolar tissue of the villus, or into the lacteals. When olive oil and choline solutions are similarly administered, and the animal examined after the same time period, masses of fat can be seen in the areolar tissue of the villus, and the cells are more rapidly cleared. The fat remaining in the cells appears to be more finely dispersed.

The effect is immediate, and occurs in animals without previous dietary restriction, except for the usual preparatory 24 hr. starvation period. The contrast is marked in spite of the probable presence of small amounts of choline derived from the bile and elsewhere in the control animals. This may be explained by the relatively large amount of olive oil used in these experiments (1 c.c.) as compared with the normal dietary fat intake of these animals. The evidence at present available does not indicate any decrease in stomach-emptying time or marked increase of intestinal movement with the doses of 2–5 mgm. of choline which have been used in these studies.



PHOTOMICROGRAPHS OF THE JEJUNUM (× 70) OF THE RAT: ABOVE, AFTER FEEDING 1 C.C. OLIVE OIL AND 1 C.C. DISTILLED WATER; BELOW, AFTER FEEDING 1 C.C. OLIVE OIL AND 1 C.C. 0·5 PER CENT CHOLINE CHLORIDE SOLUTION. ANIMALS KILLED 3 HR. AFTER FEEDING BY GASTRIC TUBE. WISTAR STRAIN MALE RATS, AVERAGE WEIGHT 200 GM. STAIN, SUDAN IV AND HÆMATOXYLIN.

The mechanism of this action of choline, and its possible relationship to normal fat absorption and to other lipotropic effects, are being investigated, and full experimental details will be published in due course.

A. C. FRAZER.

Department of Pharmacology,
University of Birmingham.
Nov. 30.

T Coronæ Borealis

THE recent outburst of the ex-nova, *T* Coronæ Borealis, first reported on February 9[1], when its magnitude was estimated to be 3·4, as against 11·3 during the immediately preceding epoch[2], has been observed at Sidmouth on three occasions only, owing to unfavourable weather conditions. Three objective-prism spectrograms of the star, secured with the 12-in. McClean prismatic camera, form the total photographic observations to date; in addition, four visual estimates of brightness were made by the aid of field-glasses.

The first observation was made through drifting cloud on the early morning of February 11 at 05 hr. U.T. At that time the visual magnitude was estimated as 3·3. The spectrogram, much under-exposed, shows little structure other than the prominent Balmer emissions at $\lambda\lambda$ 4340, 4861, and the bright bands at $\lambda\lambda$ 4640, 4686 due to N III + O II, and He II respectively. The two latter features are somewhat better defined than the Balmer lines, which are broad and diffuse. The order of intensities, as measured visually, is He II > H_γ > N III + O II, > H_β. H_δ is only just discernible.

Persistently clouded skies prevented further observation until the night of February 19–20, when the star was seen for a brief interval through a cloud-gap, and its magnitude estimated to be somewhat less than 7·0.

A second photograph was secured on the morning of March 3, by which time the star had faded still further to an estimated magnitude of 9·0. Owing to poor atmospheric transparency, and the intrinsic faintness of *T* Coronæ, it was not possible to obtain a fully exposed spectrogram. However, the exposure allowable was sufficient to reveal the main post-maximum structure, and it was noted that, again, the He II emission was the brightest feature of the entire spectrum, it having strengthened considerably. This latter observation was confirmed from an examination of the most recent photograph secured on March 10, when the stellar brightness had faded to about mag. 10·0.

No estimates of the velocity of expansion of the ejected shell have been possible on account of the poor quality of the spectrograms.

D. R. BARBER.

Norman Lockyer Observatory,
Sidmouth, Devon.
March 13.

[1] See *Nature*, **157**, 224, 261, 270 (1946).
[2] Reported by Miss F. W. Wright, Harvard Observatory. I.A.U. Circular No. 1030.

PRAGUE CONFERENCE ON THE USE OF X-RAYS IN THE METAL INDUSTRIES

THE Society of Czechoslovak Mathematicians and Physicists arranged an X-ray Conference held in Prague during November 28–December 1. About two hundred attended, and the conference had an air of warm cordiality and collaboration; lost connexions with the Western world were re-established, and the Czech X-ray workers, isolated by six years of German occupation, came into personal contact for the first time with the scientific workers of the United Nations and their publications. The conference, which was the first of its kind in liberated Czechoslovakia, was opened by Dr. M. Hampl, who greeted the foreign guests and recalled victims of the terror of the German occupation; naming Prof. V. Dolejšek, Prof. F. Ulrich, Prof. F. Záviška, Dr. Radim Nováček, Dr. Miklenda, Dr. L. Slavíková, Prof. Šimek, Dr. J. Klein, Prof. Rosický, Dr. Žadkevič, Prof. Sahánek, Dr. Köppel (see also *Nature*, **157**, 332; 1946).

In Czechoslovakia there are now about forty X-ray specialists working in various parts of the country. They are members of the Society of Czechoslovak Mathematicians and Physicists, which arranged the conference as the result of requests originating from the metal industries.

Prof. F. Slavík and Dr. V. Kunzl delivered addresses in memory of two pioneer Czech workers in the field of X-rays, who died under the German terror: Prof. F. Ulrich and Prof. V. Dolejšek. Prof. Ulrich was one of the first to use X-rays as a tool in crystallography, his work starting immediately after the First World War. Prof. Dolejšek, who died in a camp in Terezín, was an outstanding X-ray spectroscopist. As a pupil of Prof. Siegbahn, he started work on Moseley's law, and used gas tubes in the long-wave X-ray field.

The contributions to the conference will be published in full as a separate volume in Czech, with English and Russian abstracts.

Dr. J. Bačkovský (Škoda Works) discussed the biological action of X-rays and the determination of the tolerance of organisms. M. Baimler (Škoda Works) spoke on the serial testing of light-alloy castings by radiography and about the design of a modern test room with jigs for mass radiography of castings. Costing of different methods of inspection was compared. He then discussed the choice of an X-ray tube for radiography. Dr. J. Bénard (Faculté des Sciences, Paris) spoke about the increase in accuracy of the powder camera for back reflexions and its application in France to the chemistry of oxides and structure of metals. Especially interesting were the problems of the oxidation of iron and of the polishing of metals. Dr. J. Beneš (Charles University, Prague) spoke about the methods of determining the orientation of the electric axis in a crystal by Laue photographs, with application to quartz. Dr. G. W. Brindley (University of Leeds) sent a contribution dealing with a quantitative analysis by means of X-ray diffraction methods and its limitations. Prof. E. G. Cox (University of Leeds) spoke on crystallographic X-ray tubes with rotating anodes, such as have been developed at Leeds.

Dr. F. Faltus (Škoda Works) discussed the practical use of X-rays and γ-rays in welding. There is often no direct correlation between the conspicuousness of a fault and its importance; often the most dangerous faults, such as cracks, are difficult to detect. One must not overlook also the educational and the psychological element of the X-ray control on the welder. Often a saving is made by testing only selected parts of the weld, located by previous statistical analysis.

Dr. J. Feifer (Škoda Works) described how elastic and plastic deformation affects spacings, especially as shown by the back reflexion method. Deformations, translations and rotations of small grains, and also twinning, were discussed. Back reflexions are affected by these processes; the width and intensities of the diffraction lines undergo changes. Prof. A. I. Glazunov and Dr. L. Jeníček described X-ray analysis of electrolytic deposits of metals. Often a new unusual lattice of a metal appears, and X-rays are very helpful in determining its kind, deformations, grain size and orientation, helping thus to improve the technical product. Dr. J. Hrdlička dealt with the sensitivity of photographic emulsions for X-rays. Dr. L. Janko spoke about the help of radiography in a corrosion laboratory. Cavities in a layer of lead on tinned iron, intended as a corrosion protection, were detected. Under pressure, these cavities can be perforated and thus decrease the corrosion resistance of the layer. Dr. L. Jeníček spoke about the use of X-rays in the study of foundry sands, with reference to the mechanism of their binding in the wet and dry state. X-rays can be linked up with research by the electron microscope.

Dr. A. Ježek (Bata, Zlín) dealt with the fatigue of materials, which can be studied by X-rays a long time before the first cracks actually appear. X-rays reveal such changes as a shift of the mosaic, orientation of the grain, decrease of the internal strains and recrystallization, leading finally to failure. All these symptoms can be used to predict fatigue in the installations under working conditions.

Dr. F. Khol (Škoda Works) gave a review of back reflexion methods as used for precision measurement of lattice constants. A method of calculation was given. Grain size of the tested material and of the film was discussed. Errors due to film deformation can be eliminated by impressing on the film a reference net.

Dr. A. Kochanovská (Škoda Works) spoke about the splitting of the lines into several sharp components when the back-reflexion method is used with a rotated polycrystalline coarse-grain specimen. The explanation by several German authors that the splitting is due to the refraction of X-rays has proved to be wrong. It can be explained simply from the geometry of a primary beam of a finite width, from which a few strong rotating reflexions separate as a series of discrete circles. Dr. A. Kochanovská then recommended the following method for determining the deformation or anisotropy of crystals in a polycrystalline material. In an isotropic material the individual crystals are deformed in all directions equally. In an anisotropic material this is not so, and as examples measurements on steel and aluminium were given.

Dr. J. Kuba (Českomoravská, Prague) discussed the problem of protection of persons against X-rays. Protection is important from social grounds, and legal regulations are being prepared. He then spoke about the testing of bearings and bearing metals by radiography. Modern apparatus for continuous testing of bearings was described and typical faults shown.

Dr. P. Lacombe (France) contributed jointly with Prof. Guinier a paper on the use of a curved crystal as a monochromator and as a means for focusing X-rays, which in conjunction with a powder camera gives very sharp contrast photographs. Small quantities of impurities can be detected and complicated structures can be analysed.

Dr. V. Petržílka (Charles University, Prague) described an X-ray method for orientation of cut quartz crystal plates by means of an adapted Seeman spectrograph. A small indentation in its knife edge shows on the K and L lines of the spectrum on the film as black spots. The position of these spots is a function of the orientation of the crystals, and from one photograph it is possible to determine both principal angles and to control and test cut or finished quartz plates.

Dr. P. Skulari (Československá Zbrojovka, Prague) discussed the close collaboration of the X-ray worker with the engineer. By such collaboration, technological processes can be corrected and guided, density and porosity determined and casting controlled. He also described how X-ray analysis elucidated the working properties of zinc and zinc alloys which possess a hexagonal structure. This structure is sensitive to working processes. Anisotropy and twinning are also contributing causes to the working properties. The best mechanical properties are achieved by slow cold-working or by repair of the damaged structure by annealing followed by quenching. Dr. I. Smoler gave his experiences on the X-ray analysis of crystalline compounds, chiefly inorganic, by the powder method. Analysis consisted of comparison of the diffraction pattern with a standard, or calculation of the lattice. The method was applied to titanium white (rutile-anatase), to refractory materials, to cements for dentists, and many other substances. Dr. B. G. Šimek (Coal Research Institute, Prague) spoke about the radiography of coals. In black coal inorganic materials can be detected, whereas brown coal gives continuous blackening. The structure of coke can be investigated by filling its cavities with barium sulphate. Brickettes were investigated by adding lead soap in the binder. He then spoke about the X-ray analysis of coals. Reactivities of graphite and various cokes were measured and compared with X-ray results, giving the size of the crystallites. The powder method was used and the photographs measured with a recording microphotometer. Colloid dispersions of carbon in pitch and their properties were also studied.

Major J. Sterner (U.S. Army) spoke about some recent developments of apparatus for X-ray purposes, such as vibrating microphotometers, registering the first derivative of blackening, and X-ray planigraphy.

Prof. P. Urbain (Institut Ernest Denis, Prague) referred to the use of powder methods in the investigation of hydrated aluminium, magnesium and iron silicates in clays and soils. The specimens should be purified by electrophoresis with high values of electric fields to eliminate quartz, oxides and carbonates. The diffraction pattern is thus simplified. The metacolloids can then be classified according to their long spacings into four groups: Kaolinite-halloysite (6·95–9·65 A.) of aluminium type; nontronite (10–11 A.) containing iron and also aluminium; sepielite (11–13·5 A.) containing magnesium and also aluminium; montmorillonite (14–15 A.) containing aluminium and magnesium.

Dr. V. Vand (Lever Brothers, Port Sunlight) contributed a description of the progress in the construction of X-ray tubes and apparatus in Great Britain and the United States. Powder and focusing cameras and moving film techniques were also described.

M. Vinopal (Meta, Prague) gave a general outline of the evolution and history of the Czechoslovak X-ray industry.

Dr. J. Wanka (Society for Chemical and Mining Manufacture) spoke about the testing by radiography of a complicated chemical plant. Welds and boilers were tested, and as accessibility was very difficult, various methods were used. Dr. K. Waitzmann (Research and Testing Institute for Building Materials, Prague) described the testing of materials by means of γ-rays from radium, radon and mesothorium. The time of exposure is shortened by reinforcing foils. In steel and concrete, cavities of different sizes can be detected. By means of a comparison wedge, the thickness of the cavities can be determined. Mrs. Wooster (Cavendish Laboratory, Cambridge) spoke about the use of X-rays in conjunction with the Weissenberg camera in the study of orientation of crystals, and in the testing of industrial diamonds. Dr. L. Zachoval (Ako, Český Brod) sent a contribution about the methods of sensitometry of X-ray emulsions and appealed for a standardization of the procedure. A Scheiner astroboscopic disk and a source of controlled X-ray output is recommended; for lower accuracy, a wedge is sufficient.

Dr. Kunzl (Charles University, Prague) summarized the results of the meetings.

V. VAND.

VENEREAL DISEASE IN WEST AFRICA

By MAJOR R. R. WILLCOX
Late Command Venereologist, West African Command

Incidence

THE incidence of venereal disease in West African natives is very high indeed, and is rapidly on the increase. The exact number of cases in the Colonies is difficult to assess, but in British coloured troops in Nigeria, for example, the gonorrhœa rate alone was more than 60 per cent per annum; while the venereal disease rate in Gold Coast troops was 50 per cent per annum; in Sierra Leone 28 per cent; and in the Gambia as low as 12 per cent.

Gonorrhœa is by far the most common venereal disease, and the women in the larger towns are nearly all infected. The virtual total absence of facilities to treat the women on any scale at all makes the problem a most acute one. Soft sore and lymphogranuloma inguinale are both very prevalent, while syphilis, though taking fourth place, is also very rife.

Treatment Facilities

The British Army, on the whole, is organised to give adequate treatment to its personnel and to render them free from infection. The main difficulty is that the men are constantly being reinfected by the women. Some hospitals have venereal diseases clinics attached to them; while at others, such as Bathurst in the Gambia and Lagos in Nigeria, actual clinics have recently been opened. The relative numbers of female attendances at these centres are not many. Most civilian hospitals have a venereal diseases ward for males but there are usually no dark-ground condensers available for diagnostic purposes,

and most of the cases of penile sore receive neoarsphenamine until the sores are healed, and little or no after-treatment is given. The females are, as a rule, admitted to the gynæcological wards, usually only when complications have developed.

Staff shortages are acute and financially the building and staffing of clinics is expensive; therefore the civilian medical authorities, while conscious of the position, feel that the measures required to tackle it are at present beyond their powers, and that other diseases, like sleeping sickness, leprosy and—as yet to be organised on any scale—tuberculosis, should take pride of place.

Gonorrhœa

Gonorrhœa runs a similar course as in Britain, but in the West African repeated attacks are much more frequent though the incidence of complications seemed lower. Between 80 and 90 per cent responded to adequate sulphonamide dosage; but the resistant cases were very resistant indeed, though they reacted well to penicillin.

The main difficulty of sulphonamide therapy was the fact that unless the tablets were crushed and given to the men by the medical officer personally, they would often not be taken but sold in the nearest town or village for one shilling a tablet. Partly for this reason, the previous standard Army treatment at units for gonorrhœa had consisted of intramuscular injections of crushed sulphapyridine tablets, 1 gm. daily for four days, which in my experience was unsatisfactory. The difficulty was overcome by giving an adequate dose of sulphathiazole (6 gm.) in one draught daily for three days, and there then remained only twelve pints of water to be administered daily by the orderlies. Complications with sulphathiazole so administered were negligible, and all failures were sent to hospital, where latterly they received penicillin.

The improvement generally was dramatic. Success-rates claimed at units varied on the average between 80–90 per cent (one unit treated 295 cases in three months with only five failures), and hospital admissions decreased enormously. Thus there is obviously no truth in the widely disseminated rumour that the West African gonococcus is sulphonamide-resistant.

Syphilis

Opportunities of examining children were small, but though the numbers of stillbirths and abortions were high, one did not see many congenital syphilitics. Perhaps they did not survive. Primary syphilis was common and became more so as it was insisted that all sores received adequate dark-ground tests. The dark-ground tests were the only sure way of diagnosing syphilis, as in areas like Accra in the Gold Coast endemic yaws rendered serological tests unreliable for the purpose. In some weeks more than half the bloods examined showed positive reactions.

It is sometimes supposed that the existence of a positive blood test due to a previous yaws infection is a protection against syphilis. Findlay and Willcox (1945), however, successfully infected with primary syphilis a man whom one of them had treated for yaws some years previously and who had a positive Kahn reaction at the time of the experiment.

Secondary syphilis, too, was common and pustular syphilides were frequently met. Many rashes were called secondary yaws, and it was often difficult to decide which of the two disorders to diagnose; but as one saw so many primary sores and knew too that so many received inadequate treatment, one inclined toward syphilis in doubtful cases. Late syphilis was also common in the Army.

Civilian treatment for syphilis, usually after depending on Kahn test diagnosis only, was weekly neoarsphenamine until the sore had healed, and it was considered impossible or impracticable to continue after this. Army treatment was much the same at first, but has since been organised on more orthodox lines with three courses of arsenic and bismuth. The defaulter rate is, however, very high.

Penicillin will be a great boon when it becomes available for civilian use, for the Army cases responded well to the drug. As a generalization, it is not so serious for the patient to default after the penicillin course as the total treatment required for that case has usually been given. If civilian hospitals are supplied with dark-ground condensers to diagnose syphilis and penicillin with which to treat it, a very substantial move will have been made towards combating this disorder.

Soft Sore

This disease is extremely prevalent—more so than syphilis. If the basic rules are applied, namely, three negative dark-ground tests before local treatment is applied and sulphonamides administered orally, the majority heal quickly and little trouble is experienced. Associated buboes are common.

Serological tests are unreliable for excluding syphilis owing to the possible previous infection with yaws.

Lymphogranuloma Inguinale

This disease, though very common, was no real menace to troops, at any rate, though civilian medical men on the Coast said it was different in pre-sulphonamide days. One had very few chronic cases and I cannot recall boarding anyone out of the Army for this condition. I aspirated and even incised buboes and they healed without difficulty. One medical officer—a locum tenens—made long incisions on his fluctuent cases, including one European, but these too healed within two or three weeks. One can only imagine that the disease earned its bad name in the days before the sulphonamides, when surgeons made sweeping excisions of the glands. Rectal strictures occurred in females and were seen in civilian hospitals in Sierra Leone and Nigeria.

Treatment was general rather than local. Hot fomentations and the like applied to buboes appeared to be ineffective and expensive as to time and materials and personally were not used. Ulcerated groins were powdered with sulphanilamide powder and a dry dressing applied. Sulphonamides by mouth in orthodox doses were very effective indeed, and if further treatment was required, antimony in the form of 'Anthiamaline' was given. If these measures failed, a further course of sulphonamides with intravenous T.A.B. was employed. The average stay in hospital for all cases was nine days, while about 6 per cent relapsed.

Intravenous T.A.B. was well tolerated by the African though about 50 per cent showed some signs of liver damage as judged by urine and blood laboratory findings 24–48 hours after an injection.

Penicillin was tried and in small doses of 100,000–200,000 units was 60–70 per cent successful but was

not so effective as the sulphonamides. Better results were obtained in larger doses of one million units.

Other Venereal Diseases

Balanitis and penile warts were seen, but taking into account the religious ban on circumcision in many West African tribes, were less common than might be expected. Non-specific urethritis was comparatively rare, most suspected cases being attributable to gonorrhœa. I was able to find trichomonas vaginalis in several of the women I examined, while pediculosis pubis and scabies with its usual genital lesions were also common.

Of the rarer conditions, gandou was seldom seen in the Army, and as for granuloma venereum, I was only able to find one text-book case in a woman in northern Nigeria. I had none in my own department at Accra and saw none in my visits to other military hospitals.

Self-inflicted Lesions

Dishonesty as regards to property is rife in West Africa, and this dishonesty extends on a large scale to the production of self-inflicted lesions in order to avoid fatigues, postpone imprisonment or discharge from hospital, or to try to get out of the Army. This took on many forms.

Self-inflicted urethral discharge was very common; toothpaste, prophylactic tubes, whitewash, ointments and the latex of certain plants like *Euphorbia* being the commonest agents employed, while actual gonoccal pus was used by prisoners in the guard room. The absence of pus in the smear of the chemically produced cases indicated the diagnosis, and intravenous T.A.B. often exerted a salutary cure.

Penile sores were usually manufactured with battery acid or plant juices, and again *Euphorbia* played its part. If carelessly done, as was usually the case, the scattered auxiliary lesions made naked-eye diagnosis easy. If carefully done, they could be very difficult to distinguish from soft sore.

Conjunctivitis was another frequently self-inflicted lesion, and if occurring in someone already with gonorrhœa was often hard to detect, as were swollen knees induced by trauma.

Other Tropical Conditions

Several other tropical conditions infringed on the venereal field and did much to make the work interesting. Many patients with cystitis or hæmaturia, for example, had bilharzia; while many, too, suffered from filariasis, usually loa loa and often symptomless. Occasionally the adult worm was seen migrating across the conjunctiva, and once the microfilariæ of loa loa were seen while examining a blood-stained urine. Obviously, the patients with the giant scrota were not admitted to the Army, but one saw a number with the lesser grades of genital œdema. Microfilariæ, usually of loa loa, were demonstrated in the blood in the majority of these, and the attack, which usually was not the first, subsided in about a week. In one of these cases the lymphatic-borne microfilariæ of the *Onchercerca volvulus* were found in a skin scraping. The presence of the latter in the eye leads to a considerable amount of blindness in the northern territories of the Gold Coast.

Another parasite was the larva of the tumbu fly. This fly lays eggs on the ground, which are picked up by the clothes should they be allowed to dry there after washing, and larvæ from these eggs burrow into the skin, where a chrysalis develops, which with scratching leads to an infected painful sore. I saw one of these in the glans penis of a European who had complained some ten days before of having been bitten by an ant. Occasionally they may be expressed in squeezing a scrotal sore for dark-ground examination.

X-RAY SHOWING CALCIFIED GUINEA WORM IN SCROTUM

Guinea worms, too, were sometimes seen invading the genital area, and their larvæ were once identified microscopically in a discharging scrotal sore. Calcified worms were occasionally felt alongside the epididymis and could be confirmed by X-ray.

Hydroceles are very common in the African, though considering the amount of gonorrhœa it is not surprising. Also common is a pyogenic infection of the scrotum, which heals rapidly after incision and evacuation of much pus. Whether this is due in the first place to trauma, tumbu fly, guinea worm, self-infliction or to some other cause is not known.

Prophylaxis

Perhaps the most alarming factor of all is the general failure of all known methods of prophylaxis in the West African.

Prophylactic centres are a failure. In one unit where they were tried energetically, 40 per cent of the men had gonorrhœa before they used the centre and were visiting it only to protect themselves from disciplinary action before reporting sick. In another unit every man leaving the camp was given compulsory prophylactic treatment on his return whether he admitted exposure to infection or not. However, owing to men leaving the camp without permission, women being brought in, or to lack of diligence on behalf of the African orderly, there was no reduction in venereal disease there over a three months trial. In yet another unit where the prophylactic room was used enthusiastically (there being between twenty

and thirty users a night and a full-time African orderly on duty) there were in spite of this more than three hundred cases of venereal disease in three months.

Thus with an untreated heavily infected female population, and with a practically complete failure in male prophylaxis, we are up against a gigantic and grave problem. In addition, the mobilization of an army in West Africa has caused a large-scale and widespread redistribution of population with increased dissemination of these diseases. Therefore, the already vast problem is likely to increase further and further both in numbers and extent.

So far, the Colonial medical authorities find themselves unable to deal with the matter and, indeed, in many areas express themselves defeated before they have started. Postponement of facing up to this medical scourge is only making it more difficult each month that it is left, and each month the bill that will one day have to be paid mounts higher. As the Army pulls out of West Africa it will become solely the concern of the Colonial Medical Service; but by this time it will be beyond the powers of the Colonial medical officers already stationed there and of the few clinics at present erected.

It will have to be tackled as an epidemic, with maps and mobile diagnostic and treatment centres, with teams of full-time doctors and orderlies, and with litres of penicillin, treating village by village, town by town, until slowly and surely each Colony is cleared to the extent that local hospitals could hope to deal with the residue. That, I fear, will be the only way by which venereal disease will be controlled in these Colonies; it has already gone too far for other measures to hope to succeed; but such measures are, one suspects, too Utopian at the present time.

For the present, the best line is to concentrate on making one fixed class of African reasonably clean—that is, the educated African. Teach them in the schools, at the universities, and by all means possible, how to dislike and avoid venereal disease and provide the means by which they can get treated if they become infected. Then slowly, as the clerks, the telegraphists and the printers emerge from their technical training, they will become venereal disease conscious.

Unfortunately, one realizes only too well the immense difficulties, especially at the present time. All the same, one must wonder whether sufficient attention is paid to the question of venereal disease in West Africa.

FISHERIES OF JAMAICA

FROM April 1943 until October 1944, Dr. E. F. Thompson (now on the staff of the Bingham Oceanographic Laboratory) carried out an exhaustive survey of the fisheries of Jamaica with the view of assessing their needs and making recommendations for their betterment.

In an excellent and comprehensive report*, Dr. Thompson presents convincing evidence in support of his general conclusion that so far as Jamaica is concerned "there are too many men trying to catch too few fish"; that the potential of the available fishing areas is already fully exploited, and that, therefore, any extensive modernization and industrialization of the industry would lead to unemployment, increased catching and distribution costs, and no increase in production. The recommendation is therefore made that country fishermen should be encouraged to keep or renew their contacts with agriculture, so that eventually many of them may fish chiefly as an additional and subsidiary source of income and of variation of diet for themselves and their immediate neighbours.

In recommending this policy the author points out that he is well aware that it is the reverse of that generally made by advocates of modern industrialized methods. Apparently he fears disapproval of this recommendation.

He need not do so. Only where fishing grounds are inadequately exploited can modern methods be profitably introduced. To increase fishing intensity on grounds already overfished would be reprehensible and suicidal. No better advice could be tendered than that "mixed farming become a little more 'mixed' to include some farming by coastal agriculturists", and that a proportion of fishermen be encouraged to join such communities. In fact, a counterpart of the Scottish crofter-fisherman is envisaged—a type that industrialization in Britain has now all but extinguished, and Scotland is undoubtedly the worse for it.

Progress along these lines is bound to be slow and it is pointed out that, in the meantime, the greatest need of Jamaican fishermen is more in the nature of *welfare* than *development*—perhaps the most important pronouncement in the whole of the report, and applicable not only to Jamaica but also to all other backward regions where fisheries development and similar schemes are either contemplated or already in operation.

In so far as Jamaica is concerned, the aims of such welfare work are stated to be: (1) provision of an organisation through which fishermen and their problems can be handled in a natural and orderly manner; (2) the accumulation of savings to stabilize the fishermen's living and help them to assume responsibility for their own future; (3) to organise co-operative marketing; (4) to act as a liaison between fishermen and organisations working for the social and economic betterment of the people; (5) to renew and increase fishermen's contacts with agriculture and assist about four-fifths of them to drift back to agriculture from whence they came.

Dr. Thompson is under no delusion that in Jamaica—as in all other places where such development and welfare schemes are needed—all these efforts will fail in their purpose unless right and adequate responses are stimulated in those they are designed to benefit. Whether progress be achieved by the introduction of modern methods and equipment or by other means, this hard fact must always be faced—that competitive effort must be put forth with competitive zeal, enterprise and dependability. Where these are, as he found, so sadly lacking they must be evoked and developed or the outlays of both money and effort on grandiose schemes will do no more than bring about a brief and spurious prosperity to be followed by failure, disillusionment, and distress even more acute than before. All those concerned with development and welfare projects in all parts of the world would do well to ponder carefully over the final sentence in Dr. Thompson's report, "While optimism is always welcome, careful thought should be taken lest false hopes be raised and unnecessary suffering caused".

* Development and Welfare in the West Indies. Bulletin No. 18: The Fisheries of Jamaica. Report by Dr. Ernest F. Thompson. Pp. 104. (Barbados: Advocate Co., Ltd., 1945.) 30 cents.

FORTHCOMING EVENTS

Monday, April 1

SOCIETY OF CHEMICAL INDUSTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. L. P. Walls: "The Chemotherapy of Phenanthridine Compounds".

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 8 p.m.—Colonel F. C. Stern: "The Geographical Distribution of Plants".

Tuesday, April 2

BRITISH SOCIETY FOR INTERNATIONAL BIBLIOGRAPHY (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 2.30 p.m.—Mr. Denis Roberts: "Applications of the Universal Decimal Classification in the Building Industry"; Mr. G. Newman: "The Production of the Peculiar Book".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Lawrence Bragg, F.R.S.: "The Atomic Structure of Minerals".

BRITISH RHEOLOGISTS' CLUB (joint meeting with the LONDON AND S.E. COUNTIES SECTION OF THE ROYAL INSTITUTE OF CHEMISTRY, at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6.30 p.m.—Discussion on "Rheology in the Food Industry" (to be introduced by Dr. E. C. Bate-Smith ("Meat Research"), Mr. R. Drew ("Gelatine Jellies"), and Mr. J. E. Caffyn ("Dairy Produce")).

SHEFFIELD METALLURGICAL ASSOCIATION (at 198 West Street, Sheffield 1), at 6.30 p.m.—Mr. L. K. Royston: "Some Developments in High Duty Heat Resisting Steel Castings".

Wednesday, April 3

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Mr. H. P. Rooksby: "Jewels and Stones for Industrial Purposes".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Scientific Papers.

Thursday, April 4

CHEMICAL SOCIETY (at the Institution of Mechanical Engineers Storey's Gate, St. James's Park, London, S.W.1), at 2.30 p.m.—Discussion on "Some Aspects of the Chemistry of Macromolecules" (to be opened by Prof. H. W. Melville, F.R.S.).

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. J. McLean Thompson: "A Contribution to Knowledge of the Roots and Root-bearing Organs of the Forsythias"; Dr. W. G. Templeman: "Plant Growth Substances as Selective Weedkillers"; Mr. F. J. D. Thomas: "The New Insecticides, 'Gammexane' and D.D.T.".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. H. Fröhlich: "Theoretical Physics in Industry", 2: "Theory of Dielectric Breakdown".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Symposium on "Degaussing".

SOCIETY OF INSTRUMENT TECHNOLOGY (at the London School of Tropical Medicine, Keppel Street, London, W.C.1), at 7 p.m.—Mr. L. B. Lambert: "Production of Charts for Recording Instruments"; Mr. C. S. Harman: "Recorder Inks"; Mr. F. C. Knowles; "Recorder Pens".

Friday, April 5

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Edward Mellanby, K.C.B., F.R.S.: "Medical Research in War and Peace".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Symposium on "Degaussing" (continued).

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. H. E. Merritt: "The Evolution of a Tank Transmission".

GEOLOGISTS' ASSOCIATION (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Discussion on "Geology in Schools".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Newcastle-upon-Tyne), at 6 p.m.—Mr. James Calderwood: "Some Recent Developments in Internal Combustion Prime Movers".

PHOTOMICROGRAPHIC SOCIETY (at St. Martin's School of Art, 109 Charing Cross Road, London, W.C.2), at 7 p.m.—Mr. E. A. Robins: "The Spider and her Allies".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MATHEMATICS—The Secretary, Woolwich Polytechnic, Woolwich, London, S.E.18 (April 6).

TECHNICAL ASSISTANT (CHEMIST) in the Sewage Disposal Department—The Town Clerk, Guildhall, Nottingham (April 8).

ASSISTANT INSPECTORS OF FISHERIES (2, male) in the Department of Agriculture—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (April 9).

PLANT PATHOLOGIST in the Research Division, Department of Agriculture and Forests, Sudan Government—The Ministry of Labour and National Service, Technical and Scientific Register, Room 572, York House, Kingsway, London, W.C.2, quoting G.79 (April 9).

PLANT PHYSIOLOGISTS (2) for whole-time research to be carried out at East Malling Research Station—The Secretary, Research Institute of Plant Physiology, Imperial College of Science, South Kensington, London, S.W.7 (April 12).

HEAD OF THE DEPARTMENT OF CIVIL AND MECHANICAL AND MARINE ENGINEERING, Plymouth and Devonport Technical College—The Director of Education, Education Offices, Cobourg Street, Plymouth (April 13).

ASSISTANT LECTURER AND DEMONSTRATOR IN ZOOLOGY—The Principal, Royal Holloway College, Englefield Green, Surrey (April 15).

PUBLIC ANALYST AND BACTERIOLOGIST—The Town Clerk, Town Hall, Walworth Road, Southwark, London, S.E.17, endorsed 'Public Analyst and Bacteriologist' (April 15).

LECTURER IN ENGINEERING—The Registrar, University College, Southampton (April 15).

DIRECTOR OF THE COLONIAL GEOLOGICAL SURVEY—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, endorsed 'D.C.G.S.' (April 16).

JUNIOR LECTURER OR LECTURER IN THE DEPARTMENT OF PHILOSOPHY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (April 24).

SENIOR LECTURER IN THE DEPARTMENT OF PHYSIOLOGY of the University of Cape Town—The Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register, Room 572, York House, Kingsway, London, W.C.2, quoting G.83.A (April 27).

LECTURER IN GEOGRAPHY—The Registrar, King's College, Newcastle-upon-Tyne (April 27).

ASSISTANT LECTURERS (3) IN PHYSICS, and a LECTURER IN GEOGRAPHY—The Registrar, The University, Manchester 13 (April 30).

INDUSTRIAL HYGIENIST in the Department of Public Health in New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (April 30).

CHEMICAL ENGINEERS (2) for work in India to supervise erection and operation of large edible oil production and processing plants—The Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register, Room 572, York House, Kingsway, London, W.C.2, quoting F.233.XA (April 30).

UNIVERSITY LECTURESHIP IN AGRICULTURAL ENGINEERING, UNIVERSITY LECTURESHIP OR DEMONSTRATORSHIP IN AGRICULTURE, and UNIVERSITY DEMONSTRATORSHIPS IN AGRICULTURAL ENTOMOLOGY, AGRICULTURAL ZOOLOGY and PHYSIOLOGY, AND SOIL SCIENCE—The Secretary, Appointments Committee of the Faculty of Agriculture, School of Agriculture, Cambridge (April 30).

ASSISTANT TECHNICIAN, qualified in instrument making—The Secretary, Sheffield National Centre for Radiotherapy, Broom Cross, Tree Root Walk, Sheffield 10 (May 6).

LECTURER AND HEAD OF THE DEPARTMENT (subject to the general supervision of the Professor of Logic), and a LECTURER (qualified or prepared to specialize in Educational Psychology), IN THE DEPARTMENT OF PSYCHOLOGY at the United College, St. Andrews—The Secretary, The University, St. Andrews (May 15).

CHAIR OF BIOCHEMISTRY, THE CHAIR OF CHEMICAL PATHOLOGY, and the CHAIR OF PHARMACOLOGY—The Registrar, The University, Leeds 2 (May 17).

SENIOR LECTURERS and LECTURERS (subjects: Aerodynamics at high subsonic and supersonic speeds, General Physics including Electronics, General Aircraft Performance, Theory of Elasticity and Structures, General Aircraft Design, Materials and Metallurgy with special knowledge of the properties at high temperatures, Design of Jet Engines including the aerodynamics of compressors and turbines, Engine Dynamics with special reference to vibration, Mathematics especially physical applications)—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks (May 30).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Singleton Park, Swansea (May 31).

LECTURER (ungraded) IN BOTANY, and a DEMONSTRATOR (part-time) IN BOTANY—The Registrar, The University, Liverpool (June 1).

DIRECTOR—The Chairman, British Jute Trade Research Association, 5 Cowgate, Dundee (June 15).

LECTURER, and an ASSISTANT LECTURER, in PHYSICS—The Secretary, King's College, Strand, London, W.C.2 (June 30).

MORBID ANATOMIST—The House Governor, King's College Hospital, London, S.E.5 (June 30).

PROFESSORS at the Andhra University, Waltair, South India, of the following subjects: PURE MATHEMATICS, MATHEMATICAL PHYSICS, CHEMICAL TECHNOLOGY, PHARMACEUTICS, BOTANY, ZOOLOGY, PSYCHOLOGY AND APPLIED PSYCHOLOGY, COMMERCE—The Secretary, University Appointments Board, Lensfield Road, Cambridge; The Secretary, University Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1; The Master, St. John's College, Cambridge.

ORGANIC CHEMIST in the Endocrine Unit—The House Governor, London Hospital, Mile End, London, E.1.

ASSISTANT TO THE CHIEF CHEMIST—The Establishment Officer, Milk Marketing Board, Thames Ditton, Surrey.

RESEARCH ENGINEERS and APPLIED MATHEMATICIANS in the Aerodynamic, Hydrodynamic, Engine, Structures and Instrument Laboratories and Flight Research Establishment of the National Research Laboratories, Ottawa—The Chief Scientific Liaison Officer, National Research Council, Canada House, Trafalgar Square, London, W.C.2.

LECTURER IN APPLIED SCIENCE, PHYSIOLOGY AND NUTRITION—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.